An issue or revision date for this manual is shown on this page.

In the event that three years or more have elapsed between this date and the product's use, contact ZOLL Medical Corporation to determine if additional product information updates are available.

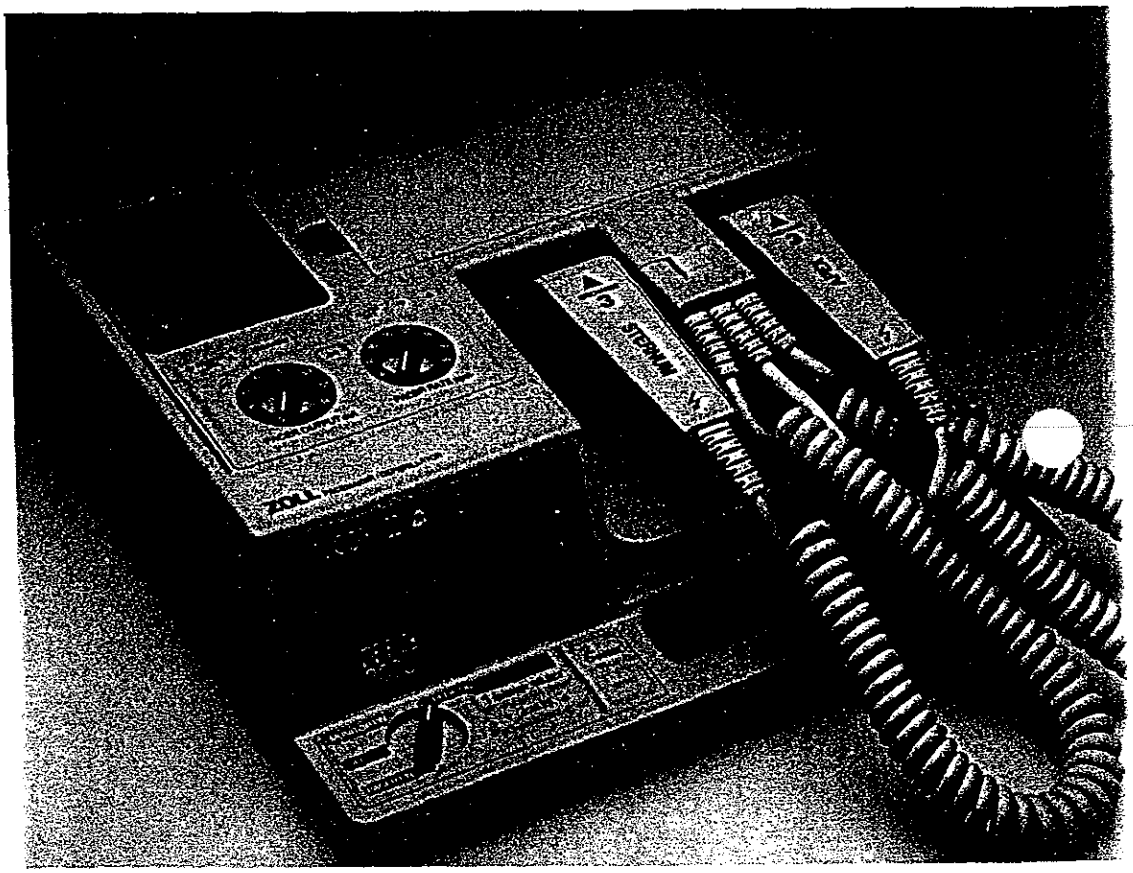
NTP, PACE-VIEW, PD, and PowerCharger are trademarks of ZOLL Medical Corporation.

Copyright 1994 by ZOLL Medical Corporation. All rights reserved. Printed in U.S.A.

Document Number 9650-0077 A November, 1994

Note: This manual applies to all PD™ 2000, D 2000, and D 1400 units, and to PD™ 1400 with a serial number of 5000 or higher. PD™ 1400 with a serial number lower than 5000 are described in the PD™ 1400 Service Manual (ZOLL part number 9650-0047).

Service
Manual



ZOLL PD™ 1400 Defibrillator/Pacemaker, PD™ 2000 Advisory Defibrillator/Pacemaker, D 1400 Defibrillator, and D 2000 Advisory Defibrillator

SECTION I

GENERAL INFORMATION

TABLE OF CONTENTS

DESCRIPTION SECTION

NOTE: This manual provides service information on the PD™ 1400, D 1400, PD™ 2000, and D 2000. Any reference to PD™ 1400-series includes PD™ 1400, D 1400, PD™ 2000, and D 2000, unless otherwise specified.
For PD™ 1400 units with serial numbers below 5000, refer to the PD™ 1400 Service Manual, ZOLL part number 9650-0047.

I. General Information

- Table of Contents I-1
- Safety Considerations I-4
- How to Use This Manual I-6
- Symbols used on the Equipment I-8
- Service Policy I-8

II. Checkout Procedures

Recommended Six-Month Checkout Procedure II-2
1. Initialize Test II-4
2. Leakage Test II-5
3. Diagnostics Mode Tests II-7
4. Power Supply Tests II-8
5. ECG Tests II-11
6. Pacer Tests (PD™ 1400 and PD™ 2000 only) II-13
7. Defibrillator Tests II-17
8. MFE Tests II-24
9. Real Time Clock Check II-26

Six-Month Checkout Procedure Data Sheet II-27

III. Troubleshooting Guides

Text Messages III-2
Status Messages III-5

IV. Functional Descriptions

1. System IV-2
2. Power Supply IV-3
3. Digital Board IV-6
3a. CPU IV-7
3b. EPU IV-10
4. Pace/Defib Board IV-13
4a. Defibrillator IV-13
4b. Pacer IV-16
5. Analog Board IV-18
5a. ECG IV-18
5b. CRT IV-20
6. Recorder IV-22

V. Schematic Drawings

1. System V-3
2. Power Supply V-4
3. Digital Module V-5
4. Analog V-13
5. Pacer/Defibrillator V-15
6. Module Interface V-16
7. Module Port V-17
8. Charger Port V-18
9. Recorder Interface V-19

VI. Component Layout Drawings

1. Power Supply VI-3
2. Digital Module VI-4
3. Analog VI-5
4. Pacer/Defibrillator VI-6
5. Module Interface VI-7
6. Module Port VI-8
7. Charger Port VI-8
8. Main Cable VI-9

9. Recorder Interface VI-10

VII. Disassembly Procedures

1. Lower Housing VII-5
2. Printer/Recorder VII-7
3. Main Cable Assembly VII-9
4. Main Control Assembly VII-11
5. CRT/Yoke Assembly VII-13
6. Pace Control Assembly VII-15
7. CRT Window VII-17
8. Display Control Assembly VII-19
9. High Voltage Multiplier Assembly VII-21
10. Module Interface PCB Assembly VII-23
11. Power Supply PCB Assembly VII-25
12. Digital PCB Assembly VII-27
CRT/ECG PCB Assembly VII-27
13. High Voltage Capacitor Assembly VII-29
14. Pace/Defib PCB Assembly VII-31
15. Patient Relay Assembly VII-33
16. Battery Harness Assembly VII-35
Battery Contact Pin VII-35
17. ECG Connector Assembly VII-37
18. Choke Assembly VII-39
19. Pace/Defib Connector Assembly VII-41
20. Paddle Guide VII-43
21. Contact Plate VII-45

VIII. Replacement Parts

• Field Replaceable Units VIII-3

APPENDIX A (OPERATOR'S MANUAL)

SAFETY CONSIDERATIONS

NOTE: Any reference to PD 1400-series includes PD 1400, D 1400, PD 2000, and D 2000, unless otherwise specified.

WARNINGS

- The following is a list of service related safety considerations. For operation related safety consideration see the Operator's Guide in Appendix A. Service Technicians should be aware of all safety considerations prior to servicing the equipment.
- **THE PD™ 1400-SERIES DEVICES SHOULD BE SERVICED BY QUALIFIED PERSONNEL ONLY!** Unauthorized persons should not attempt to service this device.
- This device can generate up to 6000 volts with sufficient current to cause lethal shocks. Please read carefully all the material contained herein before attempting service.
- Do not discharge with paddles or electrodes shorted together or in open air.
- Keep hands and all other objects clear of paddle edges when discharging.
- All persons near the equipment must be warned to "STAND CLEAR" prior to discharging the defibrillator.
- Limit internal discharges to 100 Joules or less. Do not discharge the unit more than 3 times in one minute or damage may result.
- Follow the recommended checkout procedures in Section II to ensure optimum operation of the PD™ 1400-series unit. Be sure to make thorough visual inspections, especially on cables and wires. Broken or frayed wires may cause interference or loss of signal.

WARNINGS

- Do not use ZOLL PD™ 1400-series devices in the presence of flammable agents (such as gasoline) or anesthetics. Using the instrument near the site of a gasoline spill or other solvents may cause an explosion.
- Do not discharge a PD™ 4410 battery pack except in a PD™ 4420 or compatible ZOLL Battery Charging/Testing device.

HOW TO USE THIS MANUAL

WHO IT IS FOR

The *ZOLL PD™ 1400™ -series Pacemaker/Defibrillator Service Manual* is a basic technical reference document designed for clinical engineering personnel whose responsibilities include maintenance and repair of medical equipment.

PURPOSE

Its purpose is to provide the basic information needed to allow clinical engineering staff to identify and/or repair the PD™ 1400-series to the sub-assembly (printed circuit board) level.

RECOMMENDED USE

The *Service Manual* should be readily available in the facility's equipment maintenance library. It will be used for preventive maintenance checks and for troubleshooting when problems are reported.

The *Operator's Guide,* included as Appendix A, will be used in training new operator's and for operational reference. This copy should be kept with the PD™ 1400-series Service Manual. A separately bound copy should be kept with the PD™ 1400-series device.

The *Service Manual* consists of several key sections:

Section I: General Information

This section contains a number of important notices and reference material, including safety warnings and ZOLL's warranty statement. **Be sure to review this section thoroughly before attempting to use or service the PD™ 1400-series.**

Section II: Checkout Procedures

This section contains the recommended six-month checkout procedures for the PD™ 1400-series units. This procedure should be used routinely to ensure that the unit is operating within specifications.

For daily checks and procedures, see the Operator's Manual.

Section III: Troubleshooting Guides

This section contains an operational troubleshooting section, one for use by non-technical personnel to respond to common problems detected during PD™ 1400-series operational use.

Section IV: Functional Descriptions

This section provides a basic technical description of each of the PD™ 1400-series's main subassembly modules. The information should be thoroughly reviewed before servicing.

Section V: Schematic Drawings

Major circuit board schematics are included for troubleshooting purposes.

Section VI: Component Layout Drawings

Major component layout drawings are included for troubleshooting purposes.

Section VII: Disassembly Procedures

Step-by-step instructions are provided for removing subassemblies in the event of failure.
Refer to the Service Policy in Section I for return and repair information.

Section VIII: Replacement Parts

This section contains a detailed listing of ZOLL part numbers for field replaceable parts available for the PD™ 1400-series. It will allow the service person to identify and order replacement parts. No attempt to replace parts at the component level should be attempted or the ZOLL warranty may be voided.

Appendix A: Operation

The *Operator's Manual* has been reproduced here for convenience and consistency. It should be read and understood before attempting any service procedure

SYMBOLS USED ON THE EQUIPMENT

Any or all of the following symbols may be used in this manual or on this equipment:

Type BF patient connection.

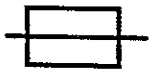
Type CF patient connection.

Defibrillation protected Type BF patient connection.

Defibrillation protected Type CF patient connection.

DANGER High voltage present.

ATTENTION Refer to manual for more information.


Fusible link.

Protective (earth) ground terminal.

SERVICE POLICY

WARRANTY

In North America: Consult your purchasing agreement for terms and conditions associated with your warranty.

Outside North America: consult ZOLL authorized representative.

In order to maintain this warranty, the instructions and procedures contained in this manual must be strictly followed.

For additional information, please call the ZOLL Technical Service Department at 1-800-348-9011.

SERVICE

The ZOLL PD™ 1400-series Pacemaker/Defibrillators and Defibrillators will provide trouble free operation without periodic recalibration or adjustment. However, it is recommended that the clinical biomedical engineering department perform routine tests of the device to verify proper operation. (See Section II.)

U.S.A. customers

Should the ZOLL PD™ 1400-series require service, contact the ZOLL Technical Service Department to obtain a return claim number. The unit should be returned, in its original container, to:

ZOLL Medical Corporation
32 Second Avenue,
Burlington, Massachusetts 01803-4420,
Attn: Technical Service Department

Loaner instruments are available for use while repairs are being completed. To request loan equipment, contact ZOLL at 1-800-348-9011 (in Massachusetts: 1-617-229-0020). Please have the following information available to expedite service:

- Unit serial number
- A description of the problem
- Department where equipment is in use
- Sample ECG strips documenting problem (if available)
- A Purchase Order to allow tracking of loan equipment
- A Purchase Order for systems out of warranty

International customers

Should the ZOLL PD 1400-series require service, it should be returned, in its original container, to the nearest authorized ZOLL Medical Corporation service center. To determine which authorized ZOLL Medical Corporation service center to use, call or fax:

ZOLL Medical Corporation
32 Second Avenue,
Burlington, Massachusetts 01803-4420,
617-229-0020 (voice)
Attn: Technical Service Department

or

617-229-0758 (fax)
Attn: Technical Service Department

SECTION II

CHECKOUT PROCEDURES

NOTE: Any reference to PD™ 1400-series includes PD™ 1400, D 1400, PD™ 2000, and D 2000, unless otherwise specified. For PD™ 1400 units with serial numbers below 5000, refer to the PD™ 1400 Service Manual, ZOLL part number 9650-0047.

Resuscitation equipment must be maintained ready for immediate use. There are two checkout procedures:

- **Daily test routine** - can be completed in a few minutes and requires no additional test equipment. The daily checkout procedure can be found in the Operator's Guide (Appendix A)
- **Extensive, six-month testing sequence** - verifies proper operation for each of the PD™ 1400-series device's major functions.

Preventive maintenance test sequences are also described in Section 8, **Operational Checks and Procedures**, in the *Operator's Guide*.

Recommended Six-Month Checkout Procedure II-2

1. Initialize Test II-4
2. Leakage Test II-5
3. Diagnostics Mode Tests II-7
4. Power Supply Tests II-8
5. ECG Tests II-11
6. Pacer Tests II-13
7. Defibrillator Tests II-17
8. MFE Tests II-24
9. Real Time Clock Check II-26

Six-Month Checkout Procedure Data Sheet II-27

Six-Month
Checkout Procedure
for the
PD™ 1400-Series

This procedure and checklist is intended for technical personnel and requires the use of additional tools and equipment.

COPY THE CHECKLIST FORM BEFORE USE!!

If a problem is discovered during the checkout procedure, use the Troubleshooting Guides in Section III to isolate or resolve the problem.

For additional assistance, contact ZOLL Technical Service Department.

SIX-MONTH CHECKOUT PROCEDURE

This section of the PD™ 1400-series Service Manual contains a series of checkout procedures to be performed by technical personnel on a routine basis (recommended for six-month intervals) to ensure quality operation of the PD™ 1400-series devices. Some tests require specialized testing equipment and trained personnel. Each test sequence lists the tools required and the frequency with which the test should be performed.

ZOLL recommends that a routine testing procedure be established for your ZOLL PD™ 1400-series equipment based on the forms supplied in this section.

TESTING NOTES

- Be sure to complete all actions for a **Step** before looking for results.
- Fill in the **Value** column on the Checkout Procedure Data Sheet with a check mark (✓) if the correct result (shown in the **Look for** column) is achieved or with a specific value where a test reading has been made.

For troubleshooting information, refer to Section III in this manual.

Recommended Six-Month Checkout Procedure II-3

1. Initialize Test II-4
2. Leakage Test II-5
3. Diagnostics Mode Tests II-7
4. Power Supply Test II-8
5. ECG Tests II-11
6. Pacer Tests II-13
7. Defibrillator Tests II-17
8. MFE Tests II-24
9. Real Time Clock Check II-26

1. INITIALIZE TEST

The Initialize Test verifies that the PD™ 1400-series unit is:

- electrically connected to a ZOLL PD™ 4410 battery or PowerCharger™
- LEDs, sensors, and message codes are operating
- recorder paper is properly installed
- date and time display is shown

1.1 INITIALIZATION

(Paddles must be installed in the unit.)

- Turn **SELECTOR SWITCH** to **MONITOR ON**.
- Listen for 4 beep audible tone.

PADDLE CHARGE LED goes on and then off.

"READY" message displayed for 4 seconds.

Mark the Checkout Procedure Data Sheet.

1.2 RECORDER CHECK

- Make sure there is no paper in the paper well.
- Press the **RECORDER ON-OFF** button.

"NO PAPER" message is displayed.

Mark the Checkout Procedure Data Sheet.

- Put a roll of paper in the paper well.
- Press **RECORDER ON-OFF** button.

"NO PAPER" message is removed and recorder operates correctly.

Mark the Checkout Procedure Data Sheet.

1.3 DATE AND TIME CHECK

- Press the **RECORDER ON-OFF** button to get a print-out on the recorder paper of the date and time.

Verify that the date and time are correct.

1.4 SET THE CORRECT DATE AND TIME. (ONLY IF NECESSARY)

Unit should be turned off.

- Press and hold the **ALARM SET** button while turning the unit to **MONITOR ON**.
- Use the **ALARM SET** up arrow and down arrow buttons to set the DATE. (Refer to the Operator's Manual.)
- Press **ALARM SET** again to input that date.

Repeat the last two steps for the MONTH, YEAR, and TIME of DAY.

- Press **ALARM SET** again. The "MONITOR" message is displayed.
- Turn off the unit.

2. LEAKAGE TESTS

EQUIPMENT REQUIRED:

- 1 red miniature alligator-to-miniature alligator test lead.
- 2 black miniature alligator-to-miniature alligator test leads.
- leakage tester.

CAUTION

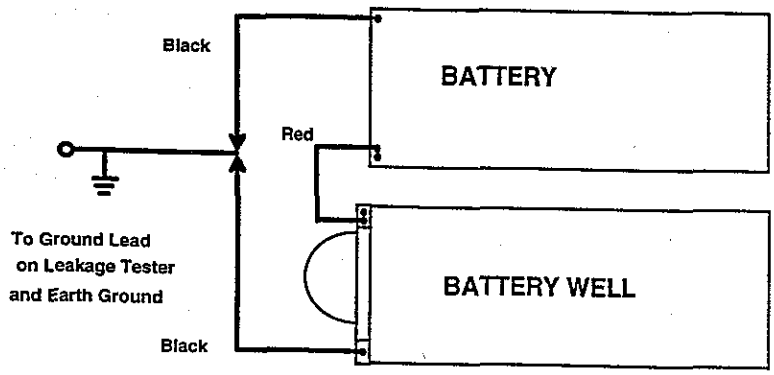
- BE SURE TO CONNECT BATTERY PROPERLY OR DAMAGE TO UNIT MAY RESULT

2.1 TEST SETUP

If a PowerCharger™ is unavailable, perform the following steps. Otherwise, use the PowerCharger™ to provide AC power and ground for leakage measurements.

Unit should be off.

- Connect one end of black lead to the ground terminal in battery well.
- Connect other end of black lead to second black lead.
- Connect other end of second black lead to "–" terminal socket of the battery.
- Connect red lead to "+" terminal socket of the battery.
- Connect other end of red lead to "+" terminal in battery well.
- Connect leakage analyzer ground lead to junction formed by two black leads.
- Turn unit to **MONITOR ON**.



2.2 LEAKAGE ACCEPTANCE LIMITS ARE AS FOLLOWS:

MAXIMUM LEAKAGE ACCEPTANCE LIMITS

ECG Leads to Ground	10 µA
Pacer Leads to Ground	10 µA
Risk Current (ECG)	20 µA
Risk Current (Pacer)	20 µA
Paddle Leads to Ground	100 µA
Paddle Risk Current	100 µA
Risk Current (ECG unshielded)	10 µA
MFC leads to ground	100 µA
MFC risk current	100 µA

3. DIAGNOSTICS MODE TESTS

Note: These tests are to be performed on PD™1400 and PD™2000 units only.

3.1 ENTER DIAGNOSTICS MODE

To power up the PD™ 1400 and/or PD™ 2000 in extended diagnostics mode:

- Press and hold the **SYNC** button for at least 7-10 seconds (until 5 beeps total are heard) while turning the **SELECTOR SWITCH** to **MONITOR ON.**
- The battery voltage will be displayed on CRT as "XXXV" (for example, "100V", which means 10.0 volts).

3.2 TEST PROCEDURE

- Turn the **SELECTOR SWITCH** to **PACER ON.**
- Set **RATE** control to 30, 80, 140 pulses per minute (ppm).
- Check that the CRT displays those values +/-8 ppm.

Mark the Checkout Procedure Data Sheet

3.3 TEST PROCEDURE

- Set the **OUTPUT** to 20, 80, 140 mA.
- Verify that the CRT displays those values +/-8 mA.

Mark the Checkout Procedure Data Sheet.

4. POWER SUPPLY TESTS

EQUIPMENT REQUIRED:

- 2 red miniature alligator-to-miniature alligator test leads.
- 1 black miniature alligator-to-miniature alligator test lead.
- Hewlett-Packard HP 63286A power supply or equivalent. (10 Amp minimum)
- 0.1Ω 1% 1/4w or greater resistor.
- 1000Ω 1% 1/4w resistor.
- Fluke 75 multimeter or equivalent.

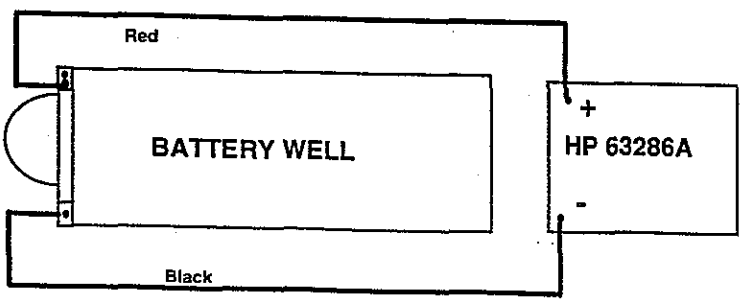
CAUTION:

- BE SURE TO CONNECT BATTERY PROPERLY OR DAMAGE TO UNIT MAY RESULT
- DO NOT RAISE THE POWER SUPPLY VOLTAGE > 12V

4.1 TEST SETUP

Unit should be off.

- Connect one end of the black lead to the ground terminal in battery well.
- Connect the other end of black lead to the "–" terminal of the power supply.
- Connect red lead to "+" terminal socket of the battery well.
- Set power supply voltage to 7V.
- Connect the other end of the red lead to the power supply.



4.2 TEST PROCEDURE

- Turn unit to **MONITOR ON**. It should not turn on.
- Turn off unit.
- Adjust power supply voltage to 9.3V.
- Turn unit on. It should now turn on.

Mark the Checkout Procedure Data Sheet.

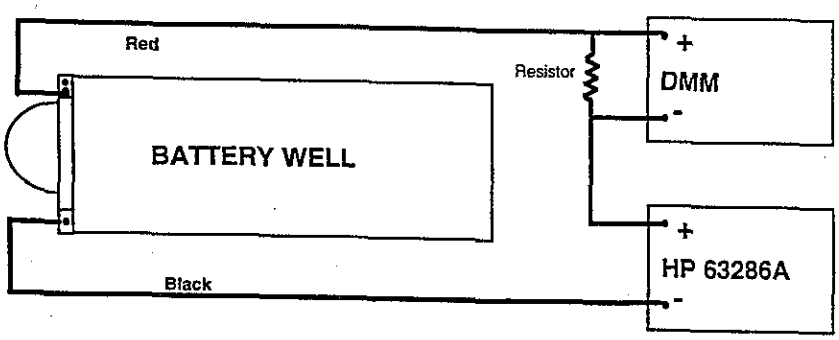
4.3 SHUT DOWN VOLTAGE TEST

- Set voltage to 9.3V. "LOW BATTERY" should be displayed within 30 seconds.
- Set voltage to 8.75V. Unit should shut off within 30 seconds.
- Turn off unit.

Mark the Checkout Procedure Data Sheet.

4.4 TEST SETUP

- Remove red lead from power supply and connect to 0.1Ω resistor.
- Connect other end of resistor to "+" terminal of power supply.
- Connect multimeter across the resistor.
- Set voltage scale (if DVM is not autoranging) to 200 mV.



4.5 SYSTEM CURRENT TEST

- Set power supply to 10V.
- Set **SELECTOR SWITCH** to **MONITOR ON**, select "PADDLES" with the LEAD button, paddles should not be installed and "PADDLE FAULT" should be displayed on the monitor.
- Voltage across resistor should be 73 mV or less (<730 mA of ON current).
- Turn unit off.

Mark the Checkout Procedure Data Sheet.

4.6 TEST SETUP

- Remove 0.1Ω resistor and replace with 1KΩ.
- Connect DMM across resistor.
- Set voltage scale to 200 mV.
- Measure voltage across resistor.

4.7 OFF LEAKAGE CURRENT TEST

- Measure across resistor with unit off.
- Voltage should be less than 170 mV (<170 µA of leakage current.)

Mark the Checkout Procedure Data Sheet.

5. ECG TESTS

EQUIPMENT REQUIRED:

- Calibrated ECG simulator with 60Hz sine wave output capability.
- Oscilloscope with probes.
- Mini-phone plug for measuring output signal from **1 Volt ECG OUT** jack.

5.1 TEST SETUP

- Set to lead I.
- Connect the ECG leads to the simulator and to the PD™ 1400-series device.
- Set the ECG Simulator to: BPM = 120, AMPLITUDE = 1 mV.
- The Heart Rate display should read 120 +/- 2 bpm.

5.2 TEST PROCEDURE

- Break each ECG lead sense line by removing each of the three leads one at a time from the simulator.

"ECG LEAD OFF" should be displayed on upper quadrant of the monitor with the removal of each of the leads.

Mark the Checkout Procedure Data Sheet.

5.3 VOLUME CONTROL TEST PROCEDURE

- Press the **BEEPER VOLUME** down button 5 times. No sound should be heard.
- Press the **BEEPER VOLUME** up button.
- QRS Detection Tone should increase in volume to an acceptably high limit.

Mark the Checkout Procedure Data Sheet.

5.4 TEST PROCEDURE

- Set **LEAD** to I and **ECG SIZE** to 1x.
- Step the **ECG SIZE** button through each setting.
- The display should change to reflect each size change.
- Mark the Checkout Procedure Data Sheet.

5.5 TEST PROCEDURE

- Set an oscilloscope as follows:

  0.5 Volts per division.

  0.2 Seconds per division.
- Plug in the mini-phone plug to the PD™-1400-series device's **1 Volt ECG OUT** jack.
- Connect the scope probe to the terminals of the mini-phone plug.

The QRS complex display should appear on the oscilloscope having an amplitude of 1 Volt +/- 0.2 V p-p.

Mark the Checkout Procedure Data Sheet.

5.6 TEST PROCEDURE

- Set **ECG SIZE** to 1x.
- Depress and hold the **ALARM SET** UP and DOWN arrow buttons to activate the calibration signal.
- Press the **RECORDER ON/OFF** button.

The strip chart should display a signal of 120 ppm with an amplitude of 10 mm +/- 1 mm.

Mark the Checkout Procedure Data Sheet.

5.7 NOTCH FILTER TEST PROCEDURE

- With the PD™ 1400-series device in **MONITOR** mode, set to LEAD I, size 3x: apply a 1 mV p-p 60Hz sine wave from the simulator to the ECG input. Note: For 50Hz-configured units, input a 50Hz sine wave.

Verify that the waveform on the recorder is less than 1.5 mm.

Mark the Checkout Procedure Data Sheet.

- Turn the ECG simulator off.

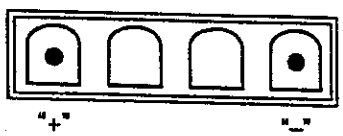
6. PACER TESTS

Note: These tests are to be performed on PD™1400 and PD™2000 units only.

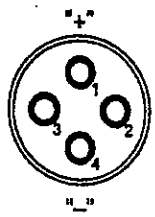
EQUIPMENT REQUIRED:

- Pacer Output Load Resistor, which consists of a 5 Watt or greater, 1KΩ resistor.
- Oscilloscope
- Signal generator
- Frequency counter
- Calibrated ECG Simulator with 60 Hz sine wave output capability

Measurements are made with an oscilloscope probe connected to the positive (sternum) side of the resistor, and with the ground of the probe connected to the negative side. See diagrams for determining polarity of pacer outputs.



Multi-Function Cable Connector



Standard Pacing Connector

6.1 ENTER DIAGNOSTICS MODE

To power up the PD™ 1400-series device in extended diagnostics mode:

- Press and hold the **SYNC** button for at least 7-10 seconds (until an additional beep is heard after the standard 4 power-up beeps) while turning the **SELECTOR SWITCH** to **PACER ON**.

6.2 TEST PROCEDURE

- Turn the **SELECTOR SWITCH** to **PACER ON.**
- Adjust **RATE** to 120 ppm.
- Connect the pacer output load resistor to the pacer output connector.
- With the frequency counter and oscilloscope connected to the test load, turn the **OUTPUT** control to 0 mA.

The display on the oscilloscope should show 0 volts.

Mark the Checkout Procedure Data Sheet.

- Set the scope as follows:

  1 Volt per division.

  0.2 or 0.5 Second per division.

- Watch the scope display while switching the **SELECTOR SWITCH** from **PACER ON** to **OFF.**

Spikes or transients should be less than 1V.

- Turn the **SELECTOR SWITCH** to **PACER ON.** Verify spikes are less than 1V.

Mark the Checkout Procedure Data Sheet.

6.3 TEST PROCEDURE

- Set the **OUTPUT** to 15 mA.
- Disconnect the pacer output load from the PD™ 1400-series device.

"PACER LEAD OFF" appears in the lower half of the display.

Mark the Checkout Procedure Data Sheet.

6.4 TEST PROCEDURE

- Reconnect the pacer output load.

The "PACER LEAD OFF" display is replaced by "PACER ON".

Mark the Checkout Procedure Data Sheet.

6.5 TEST PROCEDURE

- Set the **RATE** to 180 ppm.
- Set the **OUTPUT mA** to 0 mA.

Note the output current reading on the PD™ 1400-series device and the actual wave amplitude on the scope.

The digital display will match the **OUTPUT mA** setting

Mark the Checkout Procedure Data Sheet.

6.6 REPEAT PROCEDURE

- Repeat step 6.5 for each point setting on the **OUTPUT mA** control (20, 40, 60, 80, 100, 120, 140, MAX).
- The pulse voltage shall be 1V per mA (i.e., 20 mA = 20 +/- 8V) for each set point.

Mark the Checkout Procedure Data Sheet.

6.7 TEST COMPLETION

- Set the **OUTPUT mA** to 0.

There should be zero volts on the scope.

Mark the Checkout Procedure Data Sheet.

6.8 TEST PROCEDURE

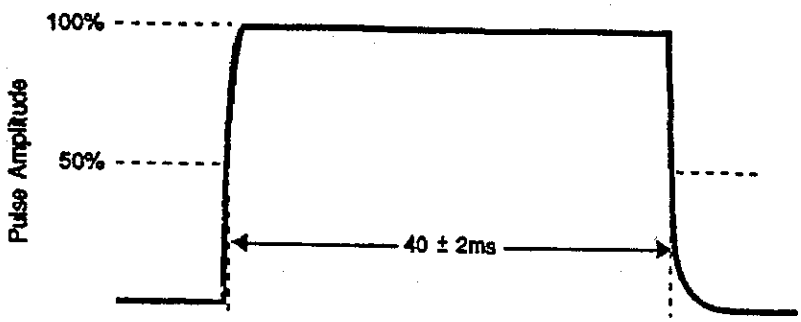
- Set **OUTPUT mA** to 60 mA.
- Measure the pulse period (frequency) and pulse width at the following RATE settings: MIN, 40, 60, 80, 100, 120, 180 and MAX (fully clockwise).

Pulse period (display) shall be within +/- 8 ppm at each setting.

The pulse width will be 40 ms +/- 2 ms at each setting.

- Measure the pulse width only where specified.

Mark the Checkout Procedure Data Sheet.



Voltage Waveform Measurement

(ppm) Dial Setting	Period Range (ms)	Pulse Width Tolerance
MIN	Record Only	38-42 ms
40	1250-1875	
60	882-1154	
80	680-833	
100	555-652	38-42ms
120	468 - 536	
180	319- 349	
MAX	Record Only	38-42 ms

6.9 MFE PACE OUTPUT TEST PROCEDURE

- Connect the MFE cable to the unit.
- Connect the test load to the MFE cable outputs.
- Connect the scope across the MFE pace output load.
- Turn the **OUTPUT** control to 60 mA and the **RATE** control to 180 ppm.

A positive-going pulse should be observed on the scope.

Mark the Checkout Procedure Data Sheet.

7. DEFIBRILLATOR TESTS

EQUIPMENT REQUIRED:

- Dynatech Nevada Impulse 3000 or equivalent defibrillator analyzer.
- Stopwatch

WARNING

- USE EXTREME CAUTION IN PERFORMING THE FOLLOWING TESTS!!!
- When performing this check using paddles, use your thumbs to operate the **DISCHARGE** buttons. No portion of the hand should be near the paddle plates.
- Keep hands and all other objects clear of paddle edges when discharging.
- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

7.1 TEST PROCEDURE

Unit should be off

- Paddles should **NOT** be in the unit. If paddles are still connected to unit, disconnect the paddle cable from the unit. Remove paddles from paddle well.

- Turn the **SELECTOR SWITCH** to **DEFIB ON**.
- Select paddles as leads.

"PADDLE FAULT" should be displayed on the CRT.

Mark the Checkout Procedure Data Sheet.

7.2 TEST PROCEDURE

- Connect the standard external defibrillator paddles to the unit. Paddles should be inserted in paddle wells.

"PADDLE FAULT" is replaced by "PADDLES"

- Select 100J using paddle energy select buttons.
- Make sure paddles are firmly in paddle well.
- Press the **CHARGE** button.

The charge time should be greater than 2s.

Mark the Checkout Procedure Data Sheet.

7.3 TEST PROCEDURE

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules may damage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press and release the APEX paddle **DISCHARGE** button only.

The unit should **NOT** discharge.

Mark the Checkout Procedure Data Sheet.

- Press and release the Sternum paddle **DISCHARGE** button only.

The unit should **NOT** discharge.

Mark the Checkout Procedure Data Sheet.

7.4 TEST PROCEDURE

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules maydamage the unit .
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press both **DISCHARGE** buttons.

The unit should discharge and the "100J RDY" message should be removed from the display.

"TEST OK" should appear on CRT and stripchart recording.

Mark the Checkout Procedure Data Sheet.

7.5 TEST PROCEDURE

- Place the Dynatech Impulse 3000 or equivalent defibrillator analyzer beside the PD™ 1400-series device.
- Place the defibrillator paddles firmly on the appropriate paddle controls of the defibrillator tester.
- Connect the PD™ 1400-series device's ECG patient cable to the DynatechImpulse 3000 defibrillator analyzer (or equivalent) output terminal jacks, observing the correct color codes.
- Press the Cardio switch (or enter synchronized cardioversion timing test mode on other testers).
- Select PADDLES as lead, **SIZE** 1x .
- Press the **SYNC** button.

Observe :

"USE LEADS" message appears briefly.

QRS complexes of 10 mm +/- 1 mm amplitude. Heart Rate = 60 bpm +/- 2.

The Heart symbol on the CRT blinks on and off at 60 bpm.

A sync marker on the monitor (a higher intensity line on the ECG R-wave peaks)

"SYNC DEFIB" is displayed on the monitor.

Mark the Checkout Procedure Data Sheet.

7.6 TEST PROCEDURE

WARNING

- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Disconnect the ECG cable from the PD™ 1400-series device.
- Set energy level to 360J using the front panel energy select button, select lead I.
- Press the **CHARGE** button on the front panel.

With a new, fully charged battery, the charge time should be less than 10 seconds.

Mark the Checkout Procedure Data Sheet.

- When the charge tone is sounded, depress and hold the **DISCHARGE** buttons on the paddles (for at least 5-10 seconds).

The PD™ 1400-series device will not discharge (because there is no ECG wave to SYNC on).

Mark the Checkout Procedure Data Sheet.

- Reconnect the ECG cable to the PD™ 1400-series device.

7.7 TEST PROCEDURE

WARNING

- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press and hold the paddle **DISCHARGE** buttons.

Observe:

The defibrillator discharges.

The ECG waveform should return to baseline within 4 seconds.

The energy displayed on the defibrillator analyzer should be 324 - 396J.

The delay time displayed on the defibrillator analyzer is 50 ms or less.

Mark the Checkout Procedure Data Sheet.

- Repeat for all energy settings.

(The limits are +/-15% or 4 Joules, whichever is greater).

7.8 TEST PROCEDURE

WARNING

- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Select "PADDLES" as lead.
- Set energy level to 360J.
- Press the **CHARGE** button. Then discharge the unit into the defibrillator tester.

The ECG display should show a negative wave following the initial transient (only if the tester has playback capabilities).

Mark the Checkout Procedure Data Sheet.

7.9 TEST PROCEDURE

- Set energy level to 360J.
- Erase any previous data stored in the summary report memory by pressing the **SUMMARY** button and the **ALARM UP-ARROW** button simultaneously for 4 seconds until "ERASING REPORT" appears on the CRT.

Mark the Checkout Procedure Data Sheet.

7.10 TEST PROCEDURE

WARNING

- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- Press the **CHARGE** button. Then discharge into a defibrillator tester.

Verify that unit successfully discharges.

Mark the Checkout Procedure Data Sheet.

7.11 TEST PROCEDURE

- Turn the unit off and then back on again.
- Press the **SUMMARY** button. The recorder should output a summary report with the correct date and time and a TOTAL SHOCKS of 1.

It should also output a defib event printout with a joules selected of 360.

Mark the Checkout Procedure Data Sheet.

7.12 TEST PROCEDURE

- Using the paddle energy level select button, select 300J.
- Using the paddle **CHARGE** button, charge the unit.
- Using the paddle energy level select button, select 360J.

Observe that the unit discharges internally

- Using the paddle energy level down select button (▼) press and observe energy level decrements each time to the next level.
- Turn on the recorder using the paddles **RECORDER** button. Verify correct time and date on recorder annotation. Turn off recorder.

Mark the Checkout Procedure Data Sheet.

8. MFE TESTS

8.1 TEST SETUP

Unit should be off.

- Disconnect the defibrillator paddles from unit.
- Install the Multi-Function Cable (MFC).
- Turn the unit to **DEFIB ON** .
- Make sure there is paper installed in the paper well.

Verify that "ELECTRODES" appears on the display.

Mark the Checkout Procedure Data Sheet.

WARNING

- **HIGH VOLTAGE!**

Keep the cable end away from human and/or metal contact.

- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules maydamage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

8.2 TEST PROCEDURE

Note: Steps 8.2 and 8.3 can be performed only on PD™2000 and D2000 units

- With the MFC installed but not plugged into the test connector, press the **ANALYZE** button.
- Verify that the message "ELECTRODE PADS OFF" and "ANALYSIS HALTED" appears on the display.

8.3 TEST PROCEDURE

- Plug the MFC into Implulse 3000 or ZOLL S-3000 simulator.
- Press the **ANALYZE** button for each of the rhythms in the table below. Check that the accompanying message is displayed for each rhythm.

Normal Sinus	**NO SHOCK ADVISED**
Ventricular Fibrillation	**SHOCK ADVISED**
Asystole	**NO SHOCK ADVISED**

8.4 TEST PROCEDURE

- Set the energy level to 2J.
- With the MFC installed but not plugged into the test connector, charge the PD™ 1400-series device to 2J.
- Press both **DISCHARGE** buttons.

Verify that the message "ELECT. PADS OFF" appears.

Mark the Checkout Procedure Data Sheet.

8.5 TEST PROCEDURE

Plug the MFC into the test connector (ZOLL part number 1004-0053).

- If the unit is not still charged, charge it to 2J.
- Discharge into the test connector.

Verify that the unit successfully discharges into the load by checking that the screen message changes back to "2J SEL"..

Mark the Checkout Procedure Data Sheet.

8.6 TEST PROCEDURE

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules maydamage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

- With the MFC still plugged into its test connector, charge the unit to 100J and discharge.

Verify: The message "TEST OK" appears on the CRT.

The message "TEST OK" appears on strip chart.

9. REAL TIME CLOCK CHECK

9.1 TEST PROCEDURE

- Press the **RECORDER ON-OFF** button to get a print-out on the recorder paper of the date and time.
  Verify that the date and time are still correct.

PD™ 1400-SERIES DEVICE CHECKOUT PROCEDURE

DATA SHEET

CIRCLE THE TYPE OF UNIT BEING CHECKED:

PD™ 2000 D 2000 PD™ 1400 D 1400

S/N _____ OPERATOR _____ DATE _____

COPY THIS FORM BEFORE USING ! !

SECTION 1. INITIALIZE TEST

Perform this Action:	Look for:	Circle the Result
1.1 *Turn the SELECTOR SWITCH to MONITOR ON.*	4 Beep Audible Tone heard.	YES NO
	Paddle Charge LED lit.	YES NO
	"READY" message displayed for 4 seconds.	YES NO
1.2 *Remove paper from recorder.*	"NO PAPER" message appears.	YES NO
Put paper into the recorder	"NO PAPER" message is removed.	YES NO
1.3 *Change date and time*	Displays correct date and time.	YES NO

SECTION 2. LEAKAGE TEST

Perform this Action:			Look for GND Normal GND Lift:	Circle the Result
2.2	ECG	Normal	_____ - _____ < 10µA	YES NO
		Reversed	_____ - _____ < 10µA	YES NO
	Pacer	Normal	_____ - _____ < 10µA	YES NO
		Reversed	_____ - _____ < 10µA	YES NO
	ECG Risk		_____ - _____ < 20µA	YES NO
	Pacer Risk		_____ - _____ < 20µA	YES NO
	Paddles	Normal	_____ - _____ < 100µA	YES NO
		Reversed	_____ - _____ < 100µA	YES NO
	Paddle Risk		_____ - _____ < 100µA	YES NO
	MFC	Normal	_____ - _____ < 100µA	YES NO
		Reversed	_____ - _____ < 100µA	YES NO
	ECG Risk (unshielded)		_____ - _____ < 10µA	YES NO
	MFC Risk		_____ - _____ < 100µA	YES NO

SECTION 3. DIAGNOSTICS MODE TESTS

Note: These tests are run on PD™1400 and PD™2000 units only.

Perform this Action:		Look for:		Circle the Result
3.1	*Power up the unit in diagnostics mode.*	5 Beeps heard.		YES NO
		Battery voltage displayed.		YES NO
3.2	*Set unit to **PACER ON**. Set **RATE** to 30, 80, 180 ppm.*	Pace rate displays	30+/- 8	YES NO
			80+/- 8	YES NO
			180+/- 8	YES NO
3.3	*Set **OUTPUT** to 20, 80, 140 mA.*	Pace output display	20+/- 8	YES NO
			80+/- 8	YES NO
			140+/- 8	YES NO

SECTION 4. POWER SUPPLY TESTS

Perform this Action:		Look for:	Circle the Result
4.2	*Power supply set at 7V.*	Unit remains off.	YES NO
	Power supply set at 9.3V.	Unit turns on.	YES NO
4.3	*Power supply set at 9.3V.*	"LOW BATTERY" message displayed within 30 seconds.	YES NO
	Power supply set at 8.75V.	Unit shuts off within 30 seconds.	YES NO
4.5	*Measure voltage across 0.1Ω resistor.*	Voltage less than 73 mV.	YES NO
4.7	*Measure voltage across 1KΩ resistor.*	Voltage less than 170 mV.	YES NO

SECTION 5. ECG TESTS

Perform this Action:		Look for:	Circle the Result
5.1	*Power up unit in self-test mode, lead I. Connect simulator to unit and set simulator to 120 bpm, 1 mV amplitude.*	Heart Rate display is 120 +/- 2 bpm.	YES NO
5.2	*Disconnect each lead and check for "LEAD OFF".*	"LEAD OFF" message displayed for each lead.	YES NO
	Repeat for lead select setting II	"LEAD OFF" message displayed for each lead.	YES NO
	Repeat for lead select setting III	"LEAD OFF" message displayed for each lead.	YES NO
5.3	*Check volume control adjustment.*	QRS Volume OFF.	YES NO
		QRS Volume ON.	YES NO
5.4	*Select lead I and step through size select.*	Lead I Size Select .5x,	YES NO
		1x,	YES NO
		1.5x	YES NO
		2x	YES NO
		3x	YES NO
5.5	*Connect scope probe to ECG OUT jack.*	ECG out is 1+/- 0.2V.	YES NO

SECTION 5. ECG TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
5.6 *Generate cal pulses on strip chart*	Cal pulse (10 mm +/- 1 mm).	YES NO
5.7 *Select lead I, size 3x. Set simulator to output 1 mV 60Hz (or 50Hz if it is a 50Hz unit).*	Recorder wave form <1.5 mm.	YES NO

SECTION 6. PACER TEST

Note: These tests are run on PD™1400 and PD™2000 units only.

Perform this Action:	Look for:	Circle the Result
6.1 *Put unit into diagnostics mode.*	5 Beeps heard.	YES NO
	Battery voltage displayed.	YES NO
6.2 *Set unit to PACER ON, 120 ppm, 0 mA output. Connect pace output load cable,frequency counter, and scope.*	Scope shows 0 mA output.	YES NO
Turn off unit and turn back on checking for transients	Scope shows Spikes/ transients < 1V.	YES NO
6.3 *Turn **OUTPUT** to 15 mA. Disconnect pacer cable.*	"PACER LEAD OFF" message displayed on CRT.	YES NO
6.4 *Reconnect pacer cable.*	"PACER LEAD OFF" message is removed.	YES NO
	"PACER ON" message is displayed.	YES NO
6.5 *Set **OUTPUT** to 0 mA..*	Pulse voltage is 0V.	YES NO

SECTION 6. PACER TEST (CONTINUED)

Note: These tests are run on PD™1400 and PD™2000 units only.

Perform this Action:	Look for:		Circle the Result
6.6 *Set **OUTPUT** to*			
20 mA +/- 8 mA	Pulse voltage is 20V +/- 8V.		YES NO
40 mA +/- 8 mA	Pulse voltage is 40V +/- 8V.		YES NO
60 mA +/- 8 mA	Pulse voltage is 60V +/- 8V.		YES NO
80 mA +/- 8 mA	Pulse voltage is 80V +/- 8V.		YES NO
100 mA +/- 8 mA	Pulse voltage is 100V +/- 8V.		YES NO
120 mA +/- 8 mA	Pulse voltage is 120V +/- 8V.		YES NO
140 mA +/- 8 mA	Pulse voltage is 140V +/- 8V.		YES NO
MAX	Pulse voltage is V +/- 8V.		YES NO
6.7 *Set **OUTPUT** to 0 mA.*	Pulse voltage is 0V.		YES NO
6.8 *Measure pulse period and width with **RATE** set to:.*	Pulse period is:	Pulse width is:	
MIN	No pulse	38-42 ms	YES NO
40	1250-1875	38-42 ms	YES NO
60	882-1154	38-42 ms	YES NO
80	680-833	38-42 ms	YES NO
100	555-652	38-42 ms	YES NO
120	468-536	38-42 ms	YES NO
140	319-349	38-42 ms	YES NO
MAX	Record only	38-42 ms	YES NO
6.9 *Connect MFE to unit, 180 ppm, 60 mA.*	Positive-going pulse is observed on the scope.		YES NO

SECTION 7. DEFIBRILLATOR TESTS

WARNING

- Limit internal discharges to 100 Joules or less. Do not discharge the PD™ 1400-series device internally more than 3 times in one minute. Multiple internal discharges at more than 100 Joules maydamage the unit.
- All persons near the equipment must be warned to "STAND CLEAR" prior to defibrillator discharge.

Perform this Action:		Look for:	Circle the Result
7.1	*Disconnect external paddles. Set **SELECTOR SWITCH** to **DEFIB ON**.*	"PADDLE FAULT" message is displayed on CRT.	YES NO
7.2	*Connect external defibrillator paddles to the unit.*	"PADDLE FAULT" message replaced by "PADDLES".	YES NO
	*Set energy level to 100J. Make sure paddles are firmly in storage wells. Press **CHARGE** button.*	Charge time greater than 2 seconds.	YES NO
7.3	*Press Apex paddle **CHARGE** button.*	"100J RDY" message displayed.	YES NO
	*Press only Apex **DISCHARGE** button*	"100J RDY" message displayed; unit does not discharge.	YES NO
	*Press only Sternum **DISCHARGE** button*	"100J RDY" message displayed unit does not discharge.	YES NO
7.4	*Press both **DISCHARGE** buttons*	Unit discharges.	YES NO
		"100J READY" message disappears.	YES NO
		"TEST OK" message appears.	YES NO
		"TEST OK" prints on strip chart.	YES NO

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
7.5 *Place paddles in the Defib tester.Select "PADDLES" as lead. Set energy level to 360J, **SIZE** = 1x. Press the **SYNC** button. Press the CHARGE buttons and discharge unit.*	"USE LEADS" message appears briefly.	YES NO
	QRS complexes of 10 mm +/- 5 mm amplitude.	YES NO
	Heart Rate = 60 BPM +/- 2.	YES NO
	Heart symbol on the CRT blinks on and off.	YES NO
	"SYNC" marker on waveform.	YES NO
7.6 *Disconnect ECG cable. Set lead I and energy level to 360J. Press **CHARGE** button and time charge.*	Charge time with fresh battery < 10 seconds. "360J RDY" message displayed	YES NO
*Press & hold **DIS-CHARGE** buttons.*	"360J RDY" message displayed unit does not discharge.	YES NO
Reconnect ECG cable.		
7.7 *Press **DISCHARGE** buttons.*	"360J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 324 - 396J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
Set energy level to 2J *Press* ***CHARGE*** *button and time charge.*	"2J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"2J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 2 - 6J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 3J *Press* ***CHARGE*** *button and time charge.*	"3J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"3J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 3 - 7J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 5J *Press* ***CHARGE*** *button and time charge.*	"5J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"5J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 1 - 9J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
*Set energy level to 7J Press **CHARGE** button and time charge.*	"7J RDY" message displayed.	YES NO
*Press **DISCHARGE** buttons.*	"7J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 3 - 11J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
*Set energy level to 10J Press **CHARGE** button and time charge.*	"10J RDY" message displayed.	YES NO
*Press **DISCHARGE** buttons.*	"10J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 6 - 14J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
*Set energy level to 20J Press **CHARGE** button and time charge.*	"20J RDY" message displayed.	YES NO
*Press **DISCHARGE** buttons.*	"20J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 16 - 24J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
Set energy level to 30J *Press* ***CHARGE*** *button and time charge.*	"30J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"30J RDY" message disappears.	YES NO
	Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 25.5 - 34.5J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 50J *Press* ***CHARGE*** *button and time charge.*	"50J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"50J RDY" message disappears.	YES NO
	Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 43.5 - 57.5J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 100J *Press* ***CHARGE*** *button and time charge.*	"100J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"100J RDY" message disappears.	YES NO
	Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 85 - 115J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:	Look for:	Circle the Result
Set energy level to 150J *Press* ***CHARGE*** *button and time charge.*	"150J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"150J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 127.5 - 172.5J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 200J *Press* ***CHARGE*** *button and time charge.*	"200J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"200J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 180 - 230J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO
Set energy level to 300J *Press* ***CHARGE*** *button and time charge.*	"300J RDY" message displayed.	YES NO
Press ***DISCHARGE*** *buttons.*	"300J RDY" message disappears. Unit discharges.	YES NO
	Baseline return in <= 4 sec.	YES NO
	Energy delivered to defib tester 255 - 345J.	YES NO
	Delay time displayed on Defib analyzer < 50 ms.	YES NO

SECTION 7. DEFIBRILLATOR TESTS (CONTINUED)

Perform this Action:		Look for:	Circle the Result
7.8	*Select PADDLES as leads. Set to 360J. Press the **CHARGE** button. Discharge the unit into the defibrillator tester.*	The ECG display shows a negative-going wave following the initial transient (if tester has "playback" capability).	YES NO
7.9	*Set energy to 360J.Press **SUMMARY** button and **ALARM UP** arrow simultaneously for 4 sec. until "ERASING REPORT" appears on CRT.*	"ERASING REPORT" message appears on CRT.	YES NO
7.10	*Press **CHARGE** button. Discharge into defibrillator tester.*	Unit discharges.	YES NO
7.11	*Turn unit off and then on Press **SUMMARY** button.*	Recorder output summary report with time and date and TOTAL SHOCKS = 1. Event Printout Joules Selected 360.	YES NO YES NO
7.12	*Select 300J with paddle energy select button.* *Charge unit with paddle **CHARGE** button.* *Select 360J with paddle energy select button.* *Press energy down (▼) for each level* *Turn on recorder with paddle **RECORDER** button.*	 Unit discharges internally. Unit decrements selected value Correct time and date displayed.	 YES NO YES NO YES NO

SECTION 8. MFE TESTS

Note: Perform steps 8.2 and 8.3 on PD 2000 and D 2000 units only.

Perform this Action:	Look for:	Circle the Result
8.1 *Install Multi-Function Cable.*	"ELECTRODES" message appears on display.	YES NO
8.2 *MFC should be installed but not connected to the test connector. Press **ANALYZE** button.*	"ELEC. PADS OFF" and "ANALYSIS HALTED" messages appear on display.	YES NO
8.3 *Connect MFC to ZOLL S-3000 simulator.*		
*Press **ANALYZE** button for Normal Sinus rhythm.*	"NO SHOCK ADVISED" message appears on CRT.	YES NO
*Press **ANALYZE** button for Ventricular Fibrillation rhythm.*	"SHOCK ADVISED" message appears on CRT.	YES NO
*Press **ANALYZE** button for Asystole rhythm.*	"NO SHOCK ADVISED" message appears on CRT.	YES NO
8.4 *Set to energy level 2J and charge. Attempt discharge (without test connector).*	"ELECTRODES OFF" message appears on CRT.	YES NO
8.5 *Plug MFC into test connector, charge to 2J and discharge.*	Unit discharges.	YES NO
8.6 *Charge to 100J and discharge.*	"TEST OK" message appears on CRT.	YES NO
	"TEST OK" message on strip.	YES NO

SECTION 9. REAL TIME CLOCK TEST

Perform this Action:	Look for:	Circle the Result
9.1 Correct date and time displayed.	Correct date and time displayed.	YES NO

SECTION III

TROUBLESHOOTING AIDS

The operational troubleshooting guide can be found in the Operator's Manual (Appendix A) This section answers many of the common problems or questions that arise during operation.

NOTE: Any reference to PD™ 1400-series includes PD™ 1400, D 1400, PD™ 2000, and D 2000, unless otherwise specified.

If trouble persists after consulting this guide, contact the appropriate technical personnel or ZOLL Technical Service Department.

Text Messages III-2

Status Messages.....III-5

PD™ 1400-SERIES TEXT MESSAGES

Text Messages	Description
PACE/DEFIB FAULT	Pace/Defib Board is Missing or Board Revision is Unsupported.
SET CLOCK	Real-Time Clock (RTC) Failure (Bad Date/time) or RTC back-up power supply Failure.
REPORT FAULT	EEPROM write failure or EEPROM Erase Failure.
REPORT FULL	Cannot store more Summary Report Data because the EEPROM is full.
ERASING REPORT	Summary Report storage being erased.
USER SETUP REQ	Both copies of the calibration or configuration data are bad and default values must be used.
LOW BATTERY	Battery pack voltage is below the absolute minimum or an acceptable threshold.
PACER LEAD OFF	Pace leads are off.
PADDLE FAULT	Paddles are selected but no Paddles/MFE are connected or they are only partially connected.
NO PAPER	No Strip Chart Recorder Paper
ECG LEAD OFF	ECG Leads Off.
BUTTON ERROR	Too many buttons pressed simultaneously.
SHORTED DISCH	Dumped more than 200J into internal DEFIB self-test shorting bar.
OPEN AIR DISCH	Capacitor voltage still high when relay returns. (Open air discharge)

PD™ 1400-SERIES TEXT MESSAGES (CONTINUED)

Text Messages	Description
CANNOT CHARGE	Both discharge buttons are pressed and charge button is pressed. Also when XSAFE = 0 and **CHARGE** button is pressed while STATUS 66 is being displayed.
CANNOT DUMP	DEFIB Capacitor voltage above target and still charging while not in charge mode.
PACE FAULT	VMON is rising in Pace Mode
TEST OK	CPU detected IPEAK test and unit passed.
TEST FAIL	CPU detected IPEAK test and unit failed.
50 J MAX	The unit will charge to a maximum of 50J with internal paddles.
ELECT. PADS OFF	Detected electrodes are off during impedance test prior to DEFIB discharge or Advisory analysis.
USE LEADS	Use ECG leads instead of paddles for synchronized cardioversion.
----------	Serial link error. Dashed lines also show up on stripchart.
SELECT DEFIB.	(PD™ 2000/D 2000 only) This message will occur if the **ANALYZE** push-button is pressed when operating in the **MONITOR ON** or **PACER ON** mode. (PD™ 2000 only). Move the selector switch to **DEFIB ON/ANALYZE** to enable the defibrillator and advisory capabiltiy.

PD™ 1400-SERIES TEXT MESSAGES (CONTINUED)

Text Messages	Description
DISABLE SYNC	(PD™ 2000/D 2000 only) Displayed if the **ANALYZE** button is pressed and the device is in SYNC DEFIB mode. The unit should be taken out of SYNC mode by pressing the **SYNC** button before attempting to activate Advisory Analysis
ANALYSIS HALTED	(PD™ 2000/D 2000 only) Analysis was halted due to either an ECG that was detected as too noisy or due to the operational mode of the unit being switched during analysis
VF ALARMS OFF	(PD™ 2000/D 2000 only) This indicates that the advisory analysis will not be performedwhen Heart rate alarms are enabled while in pace mode
SEL. ELECTRODES	(PD™ 2000/D 2000 only) Displayed if the **ANALYZE** button is pressed and the device is in SYNC DEFIB mode. The unit should be taken out of SYNC mode by pressing the **SYNC** button
ECG TOO LARGE ADJUST ECG GAIN	If the ECG signal is too large during advisory analysis, this message will prompt the user to decrease the ECG gain.
NOISY ECG RETRY ANALYSIS	This message indicates that the advisory analysis algorithm determined that the ECG signal was too noisy to properly determine the rhythm characteristics.

PD™ 1400-SERIES STATUS MESSAGES

Error Number	Description	Type of Problem
STATUS 5	EPU ROM error (displayed in diagnostic mode only)	self-test
STATUS 11	Real-Time Clock error - restart RTC.	RTC module
STATUS 15	EEPROM programming voltage low	NV memory module
STATUS 18	Strip Chart recorder failure or program logic problem.	Summary Report module
STATUS 19	First Summary Report record invalid - should erase automatically and reset	Summary Report module
STATUS 20	Summary printout aborted	Summary Report module
STATUS 26	CRT VRAM error	CRT self-test
STATUS 28	CRT board intensity	CRT self-test
STATUS 29	X-Yoke position current failure	CRT self-test
STATUS 30	Y-Yoke position current failure	CRT self-test
STATUS 31	CRT board slew intensity circuit failure	CRT self-test
STATUS 32	EPU unable to generate display text	EPU display module
STATUS 42	CPU 2.5 Reference Voltage is out of range.	CPU A/D module

PD™ 1400-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 43	CPU failed to shutdown via XPWR_KILL.	CPU Battery Monitor Module
STATUS 48	CPU ECG OUT D/A failure	self-test
STATUS 49	CPU A/D failure	self-test
STATUS 50	CPU VCTL D/A failure	self-test
STATUS 51	2.5V reference failure	self-test
STATUS 52	EPU A/D unable to converge	EPU A2D module
STATUS 56	Communication no response error	Comm module
STATUS 59	EPU failed checksum on more than 10 consecutive messages from the CPU	EPU Comm module
STATUS 61	Transmit buffer full on EPU (diagnostic mode)	
STATUS 66	EPU did not return the correct value for XSAFE 7 times in a row (if **CHARGE** button pressed, "CANNOT CHARGE" also is displayed).	Defib module
STATUS 81	Pace Amplitude pot pulled to ground or +5V.	A2D module
STATUS 82	Pace Rate pot pulled to ground or +5V.	A2D module
STATUS 88	CPU DEFIB - Capacitor Voltage is too high to discharge.	Defib module
STATUS 89	CPU DEFIB - Capacitor Voltage is greater than the absolute rated maximum.	Defib module
STATUS 90	CPU DEFIB - Unable to charge defibrillator capacitor.	Defib module

PD™ 1400-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 91	CPU DEFIB - Maximum allowable time has been exceeded without reaching target energy.	Defib module
STATUS 104	CPU and EPU target energies did not agree during defib charge.	EPU monitor module
STATUS 107	Defib cap has reached its absolute maximum voltage as detected by the EPU.	EPU monitor module
STATUS 108	During EPU monitor processing, CPU mode is other than IDLE, CHARGING, or READY. (diagnostic mode only)	EPU monitor module
STATUS 110	Pulse width greater than 16 ms as measured by EPU during defib impedance test,	EPU monitor module
STATUS 113	Target error (diagnostic mode only).	EPU monitor module
STATUS 123	During pace pulse, pulse width measured by the EPU is < 30 ms or > 50 ms. (diagnostic mode only).	EPU monitor module
STATUS 124	EPU VSNS sample or average sample is out of set limits. (diagnostic mode only).	EPU monitor module
STATUS 125	During pace pulse, pulse period as measured by EPU is < selected period minus 40 ms. (diagnostic mode only).	EPU monitor module
STATUS 126	No pace current measured by EPU within 40 ms of pace pulse marker. (diagnostic mode only).	EPU monitor module
STATUS 127	CPU is in pace mode but XPACE_SEL signal to the EPU indicates that the **SELECTOR SWITCH** is not in pace mode.	EPU monitor module

PD™ 1400-SERIES STATUS MESSAGES (CONTINUED)

Error Number	Description	Type of Problem
STATUS 134	MON_CASE error (diagnostic mode only).	EPU monitor
STATUS 138	Excessive change in defib cap energy as measured by CPU. Not a real error-diagnostic purposes in diagnostic mode only	Defib module
STATUS 140	CPU DEFIB - XSAFE Request was not echoed back by the EPU.	CPU defib module
STATUS 150	The CRT gate array program has overflowed its allotted storage.	EPU display manager
STATUS 160	CPU Stripchart Reset failed.	Stripchart
STATUS 161	CPU Stripchart Echo Test failed.	Stripchart
STATUS 162	Stripchart took too long to respond to command (diagnostic mode only).	Stripchart
STATUS 163	ECG data buffer underflow (diagnostic mode only).	Stripchart
STATUS 164	ECG data buffer overflow (diagnostic mode only).	Stripchart
STATUS 165	CPU Strip Chart Overtemperature Error.	Stripchart
STATUS 166	CPU Strip Chart Voltage is too high.	Stripchart

SECTION IV

FUNCTIONAL DESCRIPTIONS

This section describes the basic operation of the circuits and supplements the troubleshooting guides in Section III of this manual.

NOTE: Any reference to PD™ 1400-series includes PD™ 1400, D 1400, PD™ 2000, and D 2000, unless otherwise specified.

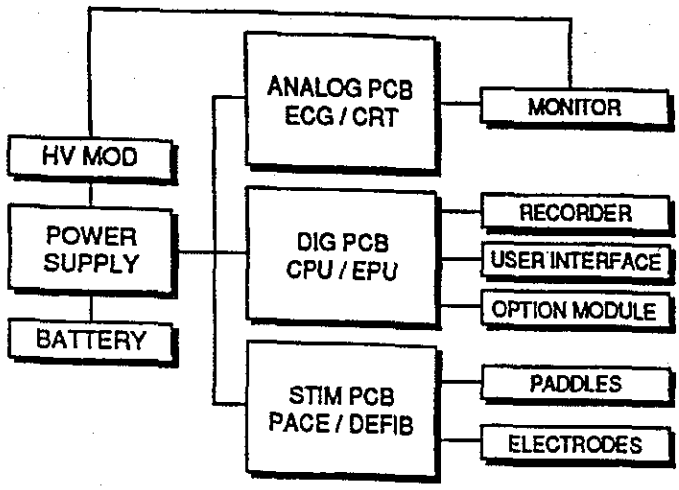
For additional information, refer to the associated schematics found in Section V.

TABLE OF CONTENTS

1. System IV-2
2. Power Supply IV-3
3. Digital Board IV-6
   a. CPU IV-7
   b. EPU IV-10
4. Pace/Defib Stimulator Board IV-13
   a. Defibrillator IV-13
   b. Pacer IV-16
5. Analog Board IV-18
   a. ECG IV-18
   b. CRT Deflection Circuit IV-20
6. Strip Chart Recorder IV-22
7. High Voltage Module (HV MOD) IV-23

1. SYSTEM

The PD™ 1400-series have a modular design philosophy. Each of the major circuits is contained on a separate assembly, which if defective, can be directly exchanged with a factory calibrated replacement.



System Diagram

The five major circuit assemblies and their functions are:

1. Power Supply

The Power Supply assembly provides the system with all voltages required. The battery current is provided by way of a fuse to this circuit.

2. Digital Board

The Digital Board assembly handles the primary instrument functions and enables interaction between the operator and the overall system. The circuit is designed around two microprocessors. The function of the CPU includes user interface, mode control, recorder, pacer pulse generation, defibrillation charge and discharge control, and code summary. The function of the EPU (ECG processing unit) includes ECG signal processing, CRT, and safety monitoring.

3. Stimulator Board

The Stimulator Board assembly includes the Pacer and Defibrillator.

The Defibrillator circuit will charge the high voltage capacitor (HVC) to the desired target energy and deliver the waveform shaped HVC energy to the patient connector. The high voltage capacitor circuit controls the shape and delivery of the energy waveform to the paddles.

The Pacer circuit provides patient isolated pacing pulses. Pulse rate and amplitude are controlled by the CPU in accordance with settings made by the front panel knobs.

4. Analog Board

The Analog Board assembly includes the ECG amplifier and the CRT deflection circuits.

The ECG circuit receives ECG information from either the three lead input or the Defibrillator patient connector. The ECG signal is then amplified and filtered for display and EPU signal processing for QRS detection.

The CRT deflection circuit controls the presentation of ECG data and character information on the CRT.

5. Recorder

The Recorder assembly prints ECG data and character information on the strip chart.

6. High Voltage Module (HV Mod)

The High Voltage Module provides all the high voltages necessary for CRT operation.

2. POWER SUPPLY

The Power Supply circuit converts the battery voltage (RAWBATT) into the supply voltages shown in the table. In addition, RAWBATT is passed through a relay to provide separate switched battery voltages SWBATT for the unit and AUX_PWR (via a second "fuse") for option modules. The Power Supply provides power and signal distribution to the Analog board (P5), Digital board (P7), Yoke (P4), CRT (P3), Option Module (P2), and High Voltage Multiplier (P1).

The voltages referred to below assume that a fully charged battery is in place. However, the Power Supply is capable of operating over a battery voltage range of 8-12 volts.

Inputs

There are three inputs to the Power Supply Module:

- RAWBATT is the voltage direct from the battery pack.
- XONOFF is taken low through the front panel switch to turn the unit on.
- XPWR_KILL is taken low by the CPU to turn the unit off when battery voltage is too low.

Outputs (other than power)

- XPWR_RESET is a warning signal from the CPU +5V supply to the CPU indicating that power loss is imminent.
- XSAF_RESET is a warning signal from EPU +5V supply to the EPU indicating that power loss is imminent.
- TEMPSENS is a measure of internal temperature
- XPWR_KILL (above).

FUSEBATT and VSAVE_PWR are always available so long as a battery pack is inserted. When a pack is removed, FUSEBATT is also removed, but VSAVE_PWR remains for several hours to support the real time clock.

Two of the voltages are stacked on top of the battery pack voltage: P8TN_PWR and RCDR_PWR. The CRT heater power floats between SWBATT and RCDR_PWR.

The 5000 volts for the CRT anode is provided by a separate voltage multiplier whose input is provided by the Power Supply 900 V Peak to Peak.

Voltages in the table are available at the same time. When the battery pack is removed, these voltages remain for a short time so that the microprocessors can complete their essential tasks.

The unconditioned battery voltage RAWBATT is used directly by the stimulator board to provide high current for pacing pulses and high voltage capacitor charging.

POWER SUPPLY VOLTAGE CHART

Output	Voltage	Use of Output
PFIV_PWR	+5	CPU
SAF5_PWR	+5	EPU
PSIX_PWR	+6.2	5 V regulators, CRT G1
MFOUR_PWR	+4.2	Yoke deflection
PFOUR_PWR	-4.2	Yoke deflection
PTWLV_PWR	+11.6	Analog, yoke deflection, isolated power for
MTWLV_PWR	-11.6	Analog, yoke deflection
SWBATT	+9 to +12	Stimulator power, Heater
RCDR_PWR	SWBATT + 5.	Recorder, Heater
P8TN_PWR	+21	Patient relay closure
PCATH_PWR	+40	CRT intensity
FOCUS_250	+250	CRT G2
FOCUS_100	+150	CRT G4
HIGH VOLTAGE	900P-P	HV multiplier

3. DIGITAL BOARD

The Digital Board includes digital and analog circuitry under control of two microprocessors, the CPU and the EPU. The functions of the board include:

Real-Time Device Control

- ECG front end
- Pace/Defib
- CRT display
- Strip chart
- Power supply
- Beeper
- Option modules

System Functions

- Non-volatile memory
- Real time clock
- ECG signal processing
- System status monitoring

User Interface

- Front panel controls
- Paddles controls

Safety Functions

- Independent monitor of the main processor
- Independent measurement of functional safety parameters

Calibration and Rest

- Calibration
- Self tests
- Safety tests

ARCHITECTURAL OVERVIEW

The CPU and EPU use separate address and data busses. Communication between CPU and EPU is on a single line network which is also shared with external modules through the Option Module Port. An I/O controller gate array shares bus with the CPU and provides device control latches and data input latches as well as timing and other functions under read/write control of the CPU. The CPU also has bus control of A/D and D/A for analog control and measurement and bus control of latches for control of other devices such as the strip chart recorder.

A CRT display controller gate array has its own RAM/ROM bus and functions as a dedicated controller. The EPU controls the display controller by writing to a CRT control latch and by writing to a bi-directional bus chip that allows the EPU and CRT controller buses to be common. The EPU also has bus control of parallel to serial and serial to parallel data conversion for ECG data and control.

3A. CPU

The CPU is the central control for the PD™ 1400series instruments. It receives information from the front panel switches and from signals internal to the instrument. After making decisions based upon the information received, it controls the operation of functional blocks such as the pacer output, defibrillator output, the strip chart recorder, the real time clock, and the non-volatile memory.

The basic hardware functional blocks associated with the CPU are as follows:

1. Front panel I/O control
2. Microprocessor (CPU, ROM, RAM, NVRAM, memory control)
3. Real time clock
4. Input and output latches
5. Analog-to-Digital conversion
6. Digital-to-Analog conversion
7. Serial communication

All the user inputs from the front panel are received by the CPU. The CPU then distributes the appropriate signals as required.

The CPU passes control requirements for ECG to the EPU by way of the serial communication link.

Operation of the pacer function is performed by having all the user setup controls received by the CPU. Signals such as pace current amplitude and pace pulse rate are converted from analog signals to digital data for microprocessor operation and manipulation.

The pacer operates as an output device controlled by the CPU. Pace current amplitude is set through a D/A converter (VCTL) and pace pulse width and rate is set by the gate array signal XPWRENB. See section 4b.

The defibrillator charging and discharging is controlled by the CPU. The CPU receives all the user inputs and performs all the required logic for safe operation of the defibrillator except for the independent safety checks performed by the EPU. Diagnostic functions concerning the proper high voltage capacitor charging and operation of the defibrillator are provided by the analog signal VCAP representing the high voltage capacitor voltage.

The defib energy delivered is calculated by the CPU from a signal derived from the wave shaping coil.

CPU HARDWARE

The CPU circuits center on a 8031 microcomputer (U27).

The CPU performs several checks on internal circuits to be sure that they are running properly including all memory locations, voltage reference and the real time clock.

All digital input signals to the CPU go to individual latches or to the on board gate array (U21). These signals are read into the RAM memory. Digital output control signals are provided on discrete latches or on the gate array (U21).

The real time clock (U58) retains date and time. When the instrument is turned off, the real time clock operates at reduced voltage and draws insignificant current from the battery. When the battery pack is removed, a large capacitor provides operating power to the real time clock for eight or more hours.

The CPU controls and monitors all the controls and switches on the instrument and the paddles or Multi-Function Cable and accessory cables. (Option module) The front panel switches are read into a matrix array of rows and columns (SWCOL0-3 and SWROW0-5) that the CPU can read through the gate array to determine which switches have been selected. The CPU also monitors the presence and identification of option modules and accessory cables.

The gate array has several independent functions collected into a single LSIC. Several of the internal functions have been described as they pertain to specific functional operations of the CPU. Additional functions in the gate array are clock divider circuits, pacer timing and control signals and an independent watchdog timer and reset circuit.

The watch dog timer provides functional safety in the event of a failure in the microprocessor program execution. If the microprocessor fails to update the watchdog timer every 4.5 msec the timer will reset the CPU.

The analog section of the CPU circuit consists of analog-to-digital (A/D) conversion and digital-to-analog (D/A) conversion. The (A/D) section has an 8 bit successive approximation converter (U16). Two multiplexers (U6 and U8) provide 16 analog inputs:

Channel 0	BEEP/PWR_STROBE	beeper
Channel 1	PADMON	paddles switches status
Channel 2	RPOT	Pacer rate-setting potentiometer voltag
Channel 3	V_PADPOT1	paddle buttons
Channel 4	VCAP	high voltage capacitor
Channel 5	V_PADPOT2	paddle type
Channel 6	IPOT	Pacer output current setting potentiom voltage
Channel 7	SWBATT	battery voltage
Channel 8	ECGOUT,VCTL_LOOP	test
Channel 9	V_X, V_Y_LOOP	test
Channel 10	TEMP_SNS	temperature
Channel 11	CHARGE	defib charge button
Channel 12	CATH_LOOP	test
Channel 13	IPEAK	defib discharge current
Channel 14	PACE_ID	test
Channel 15	25V_REF	voltage reference

The reference voltages required for both A/D and D/A are provided by 5V_REF2, derived from 25V_REF (U20).

The D/A section consists of an 8 bit CMOS converter (U22) and a buffer stage for gain and offset using op amp U23. The output signals are: ECGOUT, used for the analog 1 volt per volt ECG replica, and VCTL, the pace pulse current control signal.

A single bi-directional line is used for both transmission and reception of data between the CPU and the EPU. The connection is direct between CPU and EPU and is buffered and converted to two separate transmit and receive lines at the option module connector.

The EPU is concerned with most of the operation of ECG processing, the CPU controls ECG calibration.

3B. EPU

The EPU:

- processes ECG data received from the Analog board
- controls the presentation of messages and ECG data to the CRT
- provides an independent safety monitor of pace and defib

The basic hardware functional blocks associated with the EPU are as follows:

1. Microprocessor (EPU, ROM, RAM, memory control)
2. Input and output latches
3. Serial-to-parallel data conversion
4. Parallel-to-serial data conversion
5. Serial communication

The CPU passes ECG control data to the EPU by way of the serial communication link. The EPU controls selection of the ECG leads such as paddles, electrodes, lead I, II, or III and controls ECG size for display on the CRT.

Four lines provide the interface to the isolated ECG:

- ECG_DATA_IN — Serial eight bit ECG data.
- EDATA_OUT_CLK — Data clock for both directions of data.
- ECG_LATCH — Used to set the eight bits of the isolated side latch
- ECG_DATA_OUT — ECG control

Refer to the Analog board, ECG section 5a, for a description of these signals.

The display of data on the CRT is accomplished in two steps. First, The EPU formats the ECG data and the messages it has received from the CPU, then loads this data into a display RAM. The CRT gate array controller will then retrieve this data from RAM and use it to control the writing of messages and ECG data on the CRT. The CRT is refreshed every 16 msec during which 8 msec is used to write 1000 ECG data points and 8 msec is used to write characters.

In character mode, the controller uses the display RAM data to provide outputs of: X position, Y position, and intensity for each step that forms a vector on the CRT monitor. Switch selectable filters on the X and Y DACs provide the correct compensation for the two modes of operation, character writing and ECG trace. The DAC outputs drive current amplifiers on the Analog board which control the CRT beam deflection. Character beam intensity is controlled by modulating a single intensity bit to form a constant beam brightness independent of the beam speed. An intensity data byte sets the baseline brightness of the trace by controlling the CRT cathode voltage.

The baseline intensity is set with one intensity bit. During rapid transitions the beam appears dimmer and needs an enhancement to produce a uniform beam intensity. An analog circuit intensifies the beam during rapid vertical movements. An additional intensity bit is used to form a bright marker on the ECG trace when an R-wave is detected in the SYNC mode of machine operation.

Control of the CRT gate array is accomplished by four control lines from the EPU to the gate array and a bi-directional data bus chip. The EPU can set an address location for either the CRT RAM or ROM by setting registers in the gate array using the bi-directional data bus chip (U44). With the address location set, the bus is used to read or write from either the ROM (U55) or RAM (U56).

A status line EOMC is returned from the gate array to indicate when a string of data is completely transferred from memory to the analog circuits.

Gate Array Functions

The gate array (U52) is designed to operate independent of EPU (U3). This allows the EPU to service other tasks while the gate array drives the CRT tube deflection circuits.

To display data on the CRT tube, the gate array program counter is set to a starting address. When the array starts execution, it sequentially retrieves control words from memory which are executed until the end of message (EOMC, U3-30) command is retrieved. The array is halted until the EPU initiates another execution.

The gate array has five control registers used to drive the CRT deflection circuits, to control the beam intensity, and to set up operating modes such as clock rate and filter selection (trace vs character).

The five registers are defined as follows:

- X latch - 8 bit data to drive a DAC for horizontal beam deflection.
- Y latch - 8 bit data to drive a DAC for vertical beam deflection.
- Intensity Latch - 8 bits (U52-1 to 6, 9,10) of individually elected lines to set beam intensity and clock rate.
- Blanking shift Register - An 8 bit word is shifted out serially (U52-7, BENBO) for each new X and Y data word. This is used only during character display.
- Attribute Latch - 4 bits individually selected to control operating modes such as end of message (EOMC), blink enable, filter control (EXTR3).

The gate array can read the ROM (U55) and is capable of reading and writing RAM (U56). The RAM is used to store 1000 bytes of ECG data with an R-wave marker, store a sequence of starting ROM addresses for characters, store ROM addresses for programmed wait and move instructions, and provide a stack for subroutine operations.

To display a trace on the CRT, the gate array will retrieve a single Y data point from RAM every 8 µsec and latch it into the Y DAC register. Every 32 µsec the X DAC is incremented by one count having started at a count of 00Hex (left side of CRT display). Each Y data point also has an intensity and blanking byte to control the beam intensity. When an R-wave is detected, the sixth intensity bit (slew) is set high to further intensify the beam. For normal trace intensity the fifth intensity bit (Intfy) is set high. The blanking byte is not used in the trace mode.

During the character display mode, the gate array retrieves the character generation commands from the ROM every 4 µsec. Each command will provide an X and Y incremental movement and a blanking byte (BENBO) to control intensity. The blanking byte is modulated during each step command to provide a constant beam intensity.

To properly display ECG trace and characters, the clock rate is changed and the analog deflection filters are switched. The clock rate (OCLK) is controlled with the two high order bits of the intensity byte (EXTR1 and EXTR2) to provide 4 MHz for character and 2 MHz for ECG trace. The filter selections are controlled by the attribute bit (EXTR3).

4. PACE/DEFIB STIMULATOR BOARD

The Stimulator Board includes circuitry for patient stimulation in two modes of operation: defibrillation and pacing.

4A. DEFIBRILLATOR

The Defibrillator circuit is responsible for three major functions:

1. charging the high voltage capacitor to the level specified by the front panel setting.
2. providing feedback on the high voltage capacitor's voltage level.
3. discharging the high voltage capacitor energy through paddles or the Multi-Function Cable.

The Defibrillator portion of the stimulator Board is active only when the front panel switch is set to DEFIB ON.

Charging

A charge may be initiated in two ways - pressing the Charge button on the Front Panel or pressing the Charge button on the Paddles. When the CPU detects a charge request, it controls the charging process as follows: The defibrillator circuits begin charging the high voltage capacitor to the target voltage for the energy selected from the front panel or the Paddles select arrows and indicated on the CRT. The CPU continuously monitors the VCAP signal to ensure that the high voltage capacitor charges at the proper rate. Improper operation results in an internal dump and display of a warning message. When the target voltage is reached, the CPU initiates a continuous beeper tone to indicate that defibrillator is ready to discharge. The target energy level is displayed on the CRT screen.

The defibrillator holds the energy for 60 seconds, with the energy level being refreshed as necessary. The last ten seconds of the hold period is indicated by an intermittent beep tone. After the 60 second period, if the defibrillator has not been discharged, the energy is internally dissipated by the safety relay (XSAFREL).

Discharge

A discharge is initiated by depressing both **DISCHARGE** buttons on the paddles or on the Multi-Function Cable. This provides voltage to the patient discharge relay coil and notification to the CPU through the PADMON signal. The CPU then controls activation of the patient discharge relay. There are two exceptions to immediate discharge: operating in SYNC mode and operating with the Multi-Function Cable. In SYNC mode the discharge occurs near the peak of the ECG QRS wave. With the Multi-Function Cable, an open circuit test is first performed. If an open circuit is detected, the discharge is not allowed and the message LEAD FAULT is displayed on the CRT.

Energy delivered to the patient goes through a wave shaping inductor as specified by the AAMI Standards.

When the patient discharge relay is deactivated and the high voltage capacitor returns to system side, the safety relay is closed to internally dissipate any remaining energy .

If the PD™ 1400-series is in the self-test mode, the energy is delivered internally. The microprocessor calculates the actual delivered energy from the current waveform and displays a TEST OK message on the CRT, if the criteria for a "self-test" have been met. If the criteria are not met, a TEST FAILED message is displayed.

DETAILED CHARGING OPERATION

Initiating High Voltage Capacitor Charging

The CPU controls several signals that are used to initiate charging the high voltage capacitor. Once the stimulator board has received the signals, the board will charge the high voltage capacitor with a Pulse Width Modulator (PWM) controller (U1). The CPU will continue to monitor the changing VCAP signal to ensure proper charging operation.

All the following conditions must be satisfied before the high voltage capacitor can be charged.

1. XSAFE hi — No safety hazard detected
2. XPWR_RESET hi — Power on
3. P/XD low — Defib mode
4. XSAFREL low — Safety relay open
5. XPATREL hi — Discharge buttons not active.
6. XPWRENB low — PWM enabled

To provide safety and to improve battery operating time, the stimulator circuits are only powered when the main selector switch is in the Pace or Defib position. A high level on the signal XPWR_RESET and XSAFE will close Q100 providing power (+12) to the stimulator board.

The defibrillator capacitor is shunted for safety reasons with a resistor and relay to internally dissipate any energy remaining. When charging is initiated by the CPU, this relay is opened by providing a low level on signal XSAFREL.

P/XD sets the defib mode by disabling the pace energy driver, enabling the defib high voltage transformer driver (Q7) and setting the basic ramp time for the PWM at U1 pin 7 to set the operating frequency for flyback transformer T3.

The CPU can control the charging rate of the high voltage capacitor to improve battery efficiency by changing XLORATE. This signal affects the ramp time for the PWM by changing the capacitor to the ramp timing circuit.

When the CPU has completed set up for initiating high voltage capacitor charging, the CPU enable signal XPWRENB is set low. This signal will initiate the PWM controller. The three signals XPWRENB, XPATREL, and XSAFE are logically interlocked so that the proper combination must be present for charging to occur.

Charging Operation

The high voltage capacitor is charged by converting the system battery voltage to a pulsed high voltage by way of transformer T3. Control of this function is provided by the PWM controller (U1). It provides a basic operating frequency signal that is used to switch transistor Q7 providing current in the primary windings of the transformer T3. Efficiency is improved in charging by providing feedback of the current into the high voltage capacitor on every cycle of Q7 switching. The PWM controller is inhibited on each cycle until the high voltage capacitor current is nearly zero. This control is provided by the U3 op amp circuit. U1 pin 3 is inhibited with a high level when significant capacitor current is present.

When the high voltage capacitor is charging, the EPU independently monitors the capacitor voltage through signal VMON. If an improper level is detected, the EPU will halt operation by setting XSAFE low. This stops the PWM controller and removes power (+12) from patient relay coil, safety relay, and flyback drive.

Discharging the high voltage capacitor

Discharge of the patient relay is a two step process. The power provided to the patient relay is routed through the discharge switches on either the defibrillator paddles or on the Multi-Function Cable. The CPU then senses when the **DISCHARGE** buttons are pressed with a signal called PADMON. When the CPU has decided that all other conditions have been met, such as in the SYNC mode, it activates the signal XPATREL. This signal drives Q12 which activates the patient relay.

When the patient relay activation is complete, the CPU releases the XPATREL signal and allows the patient relay to return the capacitor terminals to the PD™ 1400-series system side. Several hundred milliseconds later, the safety relay is closed to ensure the high voltage capacitor energy is completely dissipated.

4B. PACER

The Pacer circuit produces and delivers user-controllable pace pulses to the pacing electrodes. Pacing is initiated when the front panel switch is turned to PACE and the OUTPUT and RATE controls are set. Pacing current amplitude is constant during the pulse and is determined by the position of the front panel PACER OUTPUT dial. Pacing pulse rate is determined by the position of the front panel PACER RATE dial. The pacing pulse duration is fixed at 40 msec.

The CPU provides five signals used by the Pacer circuit. They must be as indicated for pace pulses to be generated:

1. XSAFE hi — No safety hazard detected (EPU)
2. XPWR_RESET hi — Power on
3. P/XD hi — Pace mode
4. XLORATE low — Pace charging rate
5. XPWRENB low — PWM enabled during pulse
6. VCTL — Sets current amplitude

The CPU provides two signals to control the pacing pulse:

VCTL sets the pacing current amplitude. It is an analog signal derived from the position of the front panel pace pot PACER OUTPUT. Current sense transformer T1 and operational amplifier U3 measure actual pacing current (VPACE) and compare it to VCTL to provide loop control.

XPWRENB is a digital signal turned on and off by the CPU to start and stop the pacing pulse. The CPU sets the pace pulse duration by the XPWRENB on time and the pace pulse rate by the XPWRENB on-to-on interval.

Outputs

The signal LEADOFF is sent from U10 to the CPU when the pace current times the patient resistance exceeds about 300V ± 15%. This is used to detect Pacing leads off.

The pace pulse output goes to the pacer output connector on the paddles set or to the Multi-Function Cable.

Independent safety monitoring is provided by the EPU. An independent measure of pacing current is provided in the signal VSNS. It is derived from a second current sensing transformer T2 and op amp U8. In Pace mode VSNS must indicate the selected pacing current. If the expected condition is not reached, the EPU stops the PWM controller and removes +12 volts by way of XSAFE.

5. ANALOG BOARD

The Analog Board consists of two sections, ECG, and CRT deflection.

5A. ECG

The ECG has a system circuit side and a patient isolated side. On the patient isolated side there are two inputs for ECG signals. Paddle input protection is offered by series resistors and voltage limiting components. The three lead ECG input is protected with voltage transient suppressers, the lead select relays, series resistors, and diode clamps. The three lead input is sensed for a leads off condition. Both ECG inputs (leads and paddles) follow the same signal conditioning path after the lead select relays. The signal path consists of RF input filtering, an instrumentation amplifier, a slew limiting stage, a gain and 100 Hz low pass stage, and then an analog to digital serial data conversion for transmission over the patient isolation barrier to the system side. Other circuits on the isolated side include leads off, hi slew detection, gain and bandwidth selection, and drive circuits for the lead select relays.

The system side circuits consist of minimal signal conditioning and the power supply drive. The isolated power supply runs at 50 kHz from the +11.6 V regulated supply.

Input Protection

The ECG patient connections are protected with voltage transient suppressers at each of the three input leads and at the paddles input. A second level of protection for the op amp inputs is accomplished with series input resistors and diode clamps to the power supply rails. Current source resistors (R7, R8) are used for ECG leads off detection. Protection between the paddles inputs and the three lead inputs is achieved by the series resistors, Zener diodes (D21, D22), MOVS (M1, M2, M3), and the lead select relay (K1). The MOVs limit the voltage if an external defibrillation voltage is applied from the paddle to any of the three ECG leads.

Lead Selection

Inputs from the ECG amplifiers may come from the three standard ECG leads or from the defibrillation paddles. These inputs go to the lead select relay (K1,) and selection multiplexers (U6, U7) to provide the standard lead configurations of lead I, II, or III and to select the paddles input. The relay also provides isolation of the paddles inputs and the three ECG leads.

The lead select relay is of a latching configuration with the relay having a separate set and reset coil. These coils are driven by FET switch Q2 and latch bit LEAD_DRV. The relay state selected is determined by latch bits LEAD(0) and LEAD(1). Multiplexer select bits are provided by the output of latch U4; bits are latched via LEAD (1:0) and FET switch Q2.

The multiplexer outputs are filtered prior to the first stage instrumentation amp (U2). The instrumentation amp configuration provides excellent common mode rejection by using precision matched gain resistors. The first stage instrumentation amplifier has a gain of 14. The second stage after the instrumentation amplifier (U3) provides a dual function. First, it limits the slew rate of the signal before it can pass to subsequent stages. This happens when the input signal exceeds 1 v/sec due to events such as internal pace pulses or noise. The second function is to provide a signal to the high slew detection circuit (U5) when high slew signals are present.

Leads Off

Disconnected ECG leads on RA, LA, and LL leads are detected. The paddle lead is terminated so a paddle leads off status cannot be detected. For the three ECG inputs, the leads off status is detected when current source resistors (R7, R8) drive the input voltage out of bounds. During paddle monitoring, leads off is not detected on the three lead ECG. It is also possible to get a leads off message when a signal larger than approximately 0.5 volts is applied to either the three ECG leads or the paddles input.

The leads off status is detected from each of the three op amps (U2, U3b) in the instrumentation amp. This will cover all possible combinations of removed leads. These three signals are diode OR'ed together and are the input to the leads off detection circuit (U8). When either of the two input op amps drops below approximately -8.75 volts or if the differential op amp stage output exceeds +/- 8.75 volts the leads off signal is sent to the EPU by clamping the serial data signal (ISO4).

Hislew

The second stage amplifier of the ECG signal provides a slew limit of 1 volts/second by saturating the ECG signal above this slew rate, as for example, when there is a pacing pulse.

Electrode Impedance Measurement

The electrode-to-electrode impedance is measured by injecting a low-level, high-frequency AC current into the electrodes via transformer T2. The induced voltage at the electrodes is sensed via a demodulator circuit (U10 and peripheral components) and measured by the EPU on its A/D, ACH7.

ECG Data Interface

Four optoisolators provide the interface to the isolated side:

Output	ECG_DATA_IN	Serial eight bit ECG data.
Input	EDATA_OUT_CLK	Data clock for both directions of data.
Input	ECG_LATCH	Used to set the eight bits of the isolated side latch:
Input	ECG_DATA_OUT	ECG control word
two bits:		four lead combinations I, II, III, paddles
three bits:		eight ECG amplifier gains
two bits:		three bandwidths
one bit:		LEAD_DRV, strobes lead select relays.

System Side

Power Supply for Patient Isolated Circuits

The supply chopper signal is provided by the CPU gate array at 50 kHz. The signal is buffered (Q117, Q119) to drive the power chopper.

5B. CRT DEFLECTION CIRCUIT

Deflection

Two similar deflection circuits receive X and Y deflection analog voltages from the EPU and convert them to deflection currents to drive the CRT beam. These circuits are based on operational amplifiers which convert input voltage to current in the range of 0.6 amps and include filtering to remove DAC steps and provide compensation.

Both circuits operate in high and low power modes to conserve battery capacity. With slow beam movement, power is derived from +/- 4.2 volt supplies. When the beam is required to move rapidly, power is switched momentarily to +/- 11.6 volts to achieve more rapid change in deflection coil current.

CRT Intensity Control

The intensity control circuits have three operational sections. They are a high slew signal which is a rectified signal proportional to beam rate of change, INT_2, a high slew inhibit switch, and an adjustable current source (Q100 and R123) to control cathode voltage.

To display an ECG trace, there are three intensity controls implemented. The proper baseline intensity is selected with the intensity bit (INTFY). When vertical deflection is fast, the beam speed on the phosphor causes the trace to appear dim so an analog high slew signal proportional to beam speed is used to increase the beam intensity, resulting in a uniform ECG trace display. To indicate an R-wave detection by the CPU, an additional intensity bit (SLEW) is used to substantially increase the beam intensity. This results in a very bright segment of trace where the R-wave was detected.

To display characters only BENBO is used to control the adjustable current source and INT_2 is turned on to prevent the analog beam slew detector circuit from having an effect.

6. STRIP CHART RECORDER

The strip chart is a General Scanning AR-42. Data are transferred in either direction on an eight bit bus. Control lines are:

STR_XWR	writes data to strip chart
STR_XWRRDY	ready to receive data
STR_XRD	reads data from strip chart
STR_RDRDY	data ready to be read
STR_ERR	error has occurred
XSTR_RST	resets strip chart
STR_SYNC	generates interrupt to CPU
STR_RDBK(0)	indicates which status word is available
STR_RDBK(1)	indicates which status word is available

The strip chart is controlled by the CPU and receives all its data from the CPU. The CPU buss is made common to the strip chart through the bi-directional buss chip U15. The recorder communicates STR_SYNC (interrupt) and two status bits indicating which of four status bytes is available direct to the CPU or CPU gate array. The CPU provides a direct line to reset the strip chart (XST_RST). Read and write signals are provided only when needed. Three control signals, STR_XWRRDY, STR_XRDRDY, and STR_ERR are provided when strip chart control latch U24 is selected by the CPU.

SECTION V

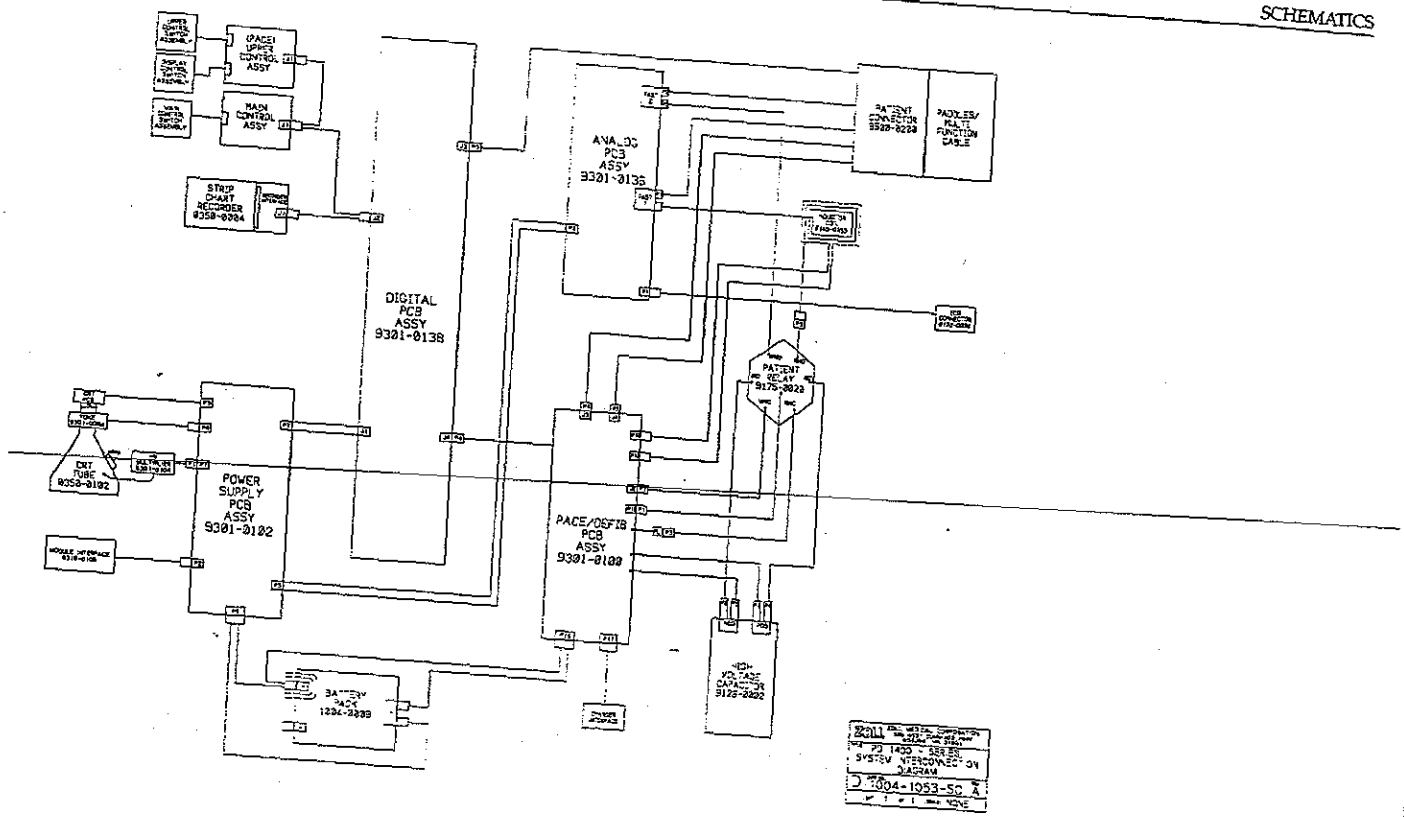
SCHEMATIC DRAWINGS

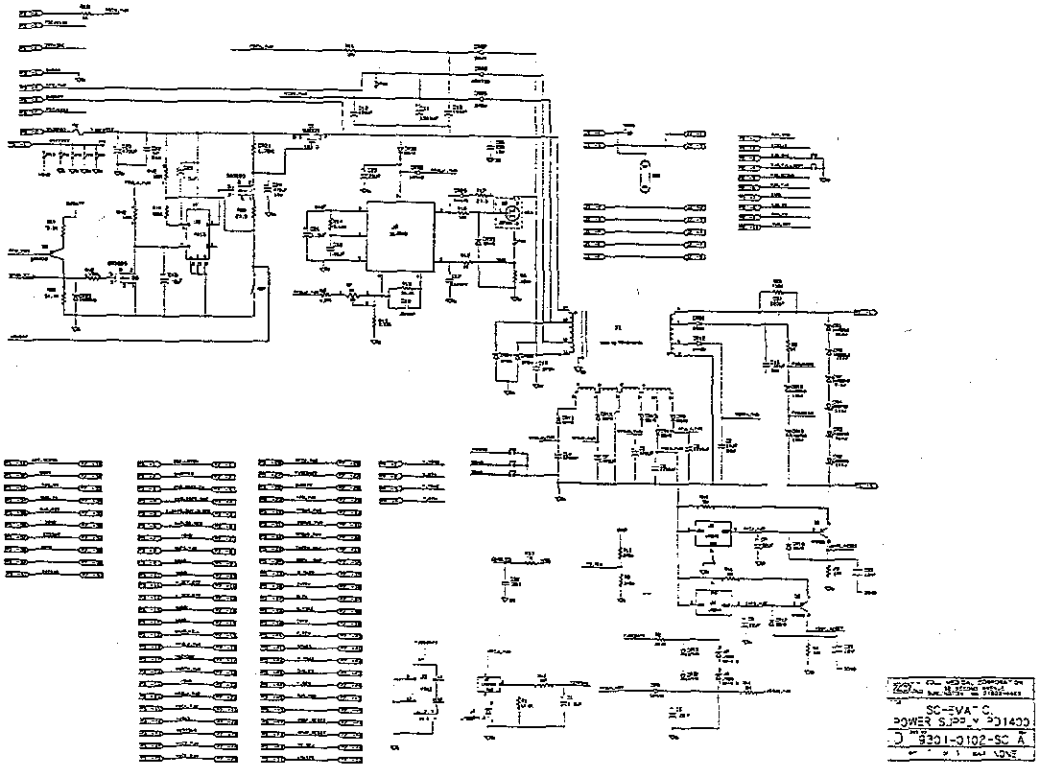
PD 1400 schematic drawings are included here to supplement the information presented in:

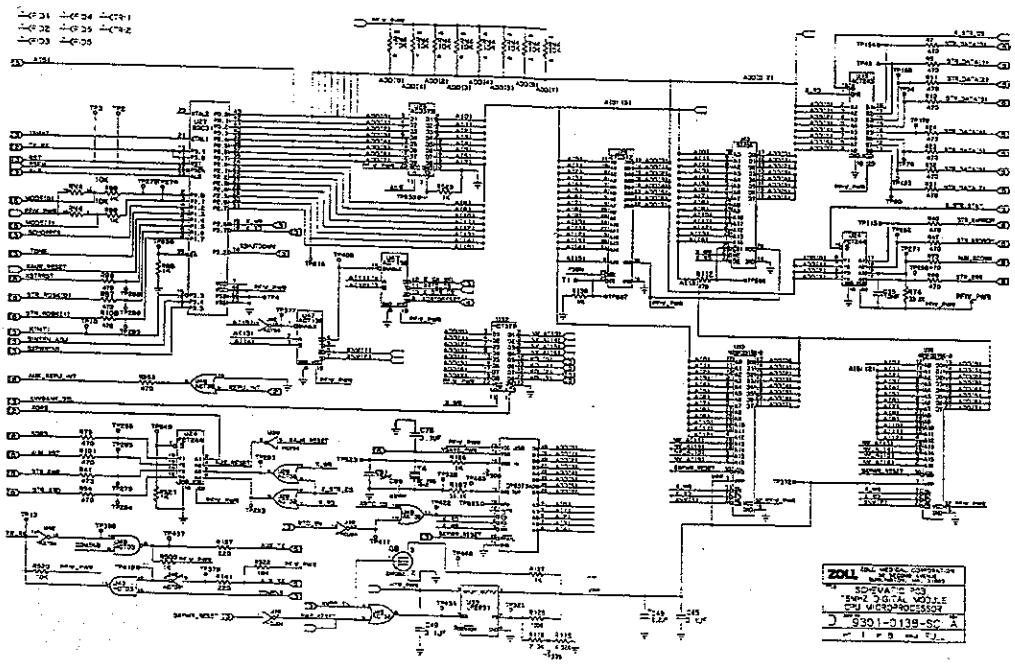
- Section III, Troubleshooting
- Section IV, Functional Descriptions
- Section VI, Component Layout Drawings

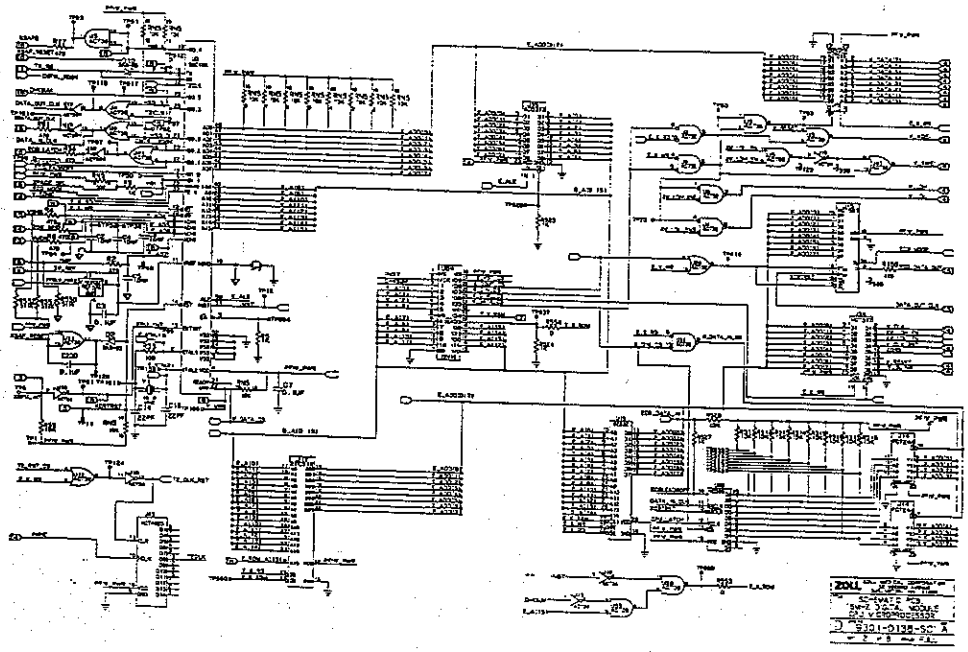
LIST OF DRAWINGS

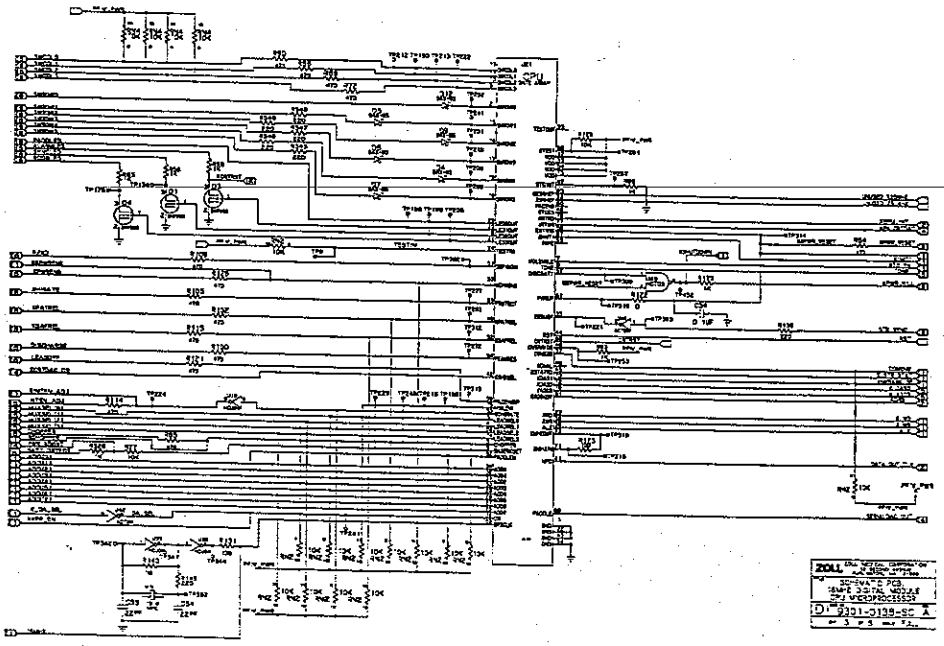
Description	Drawing No.	Page
1. System	1004-1048	V-3
2. Power Supply	9301-0102	VI-4
3. Digital Module	9301-0138	VI-5
4. Analog	9301-0136	V-13
5. Pacer/Defibrillator	9301-0100	V-15
6. Module Interface	9301-0106	V-16
7. Module Port	9301-0036	V-17
8. Charger Port	9301-0027	V-18
9. Recorder Interface	9301-0107	V-19

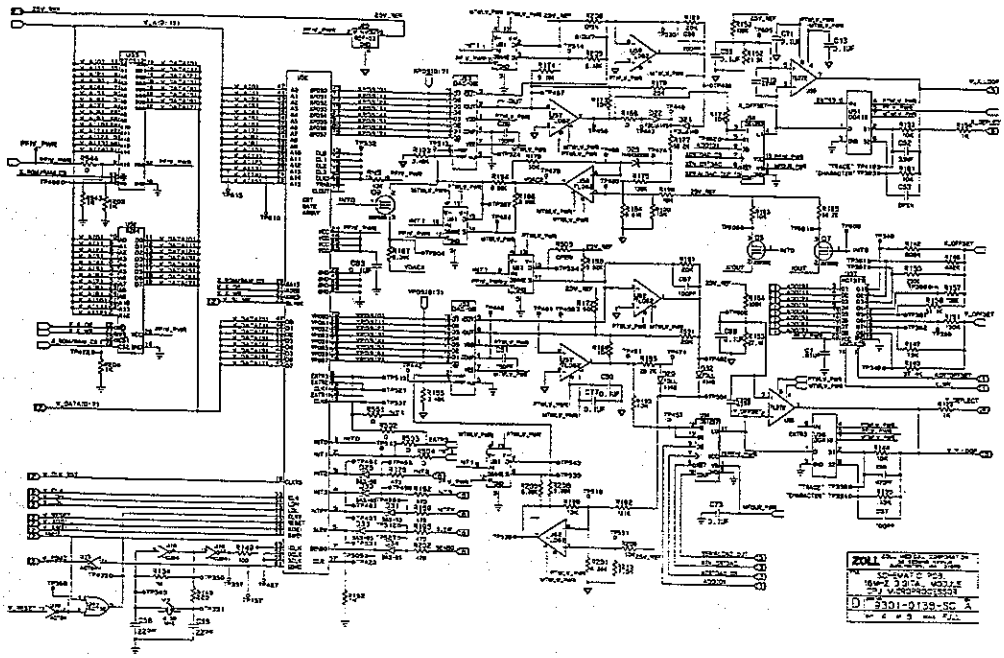

PACER/ DEFIB CONTROL ASSY
MAIN CONTROL ASSY
STRIP CHART RECORDER 9358-0204
DIGITAL PCB ASSY 9301-0138
ANALOG PCB ASSY 9301-0135
PATIENT CONNECTOR 9320-0228
PADDLES/ PACE FUNCTION CABLE
PATIENT RELAY 9175-0023
CRT TUBE 9358-0192
POWER SUPPLY PCB ASSY 9301-0132
PACE/DEFIB PCB ASSY 9301-0100
BATTERY PACK 1284-2339
HIGH VOLTAGE CAPACITOR 9125-0202
SYSTEM INTERCONNECTION DIAGRAM
D 1004-1053-SC A

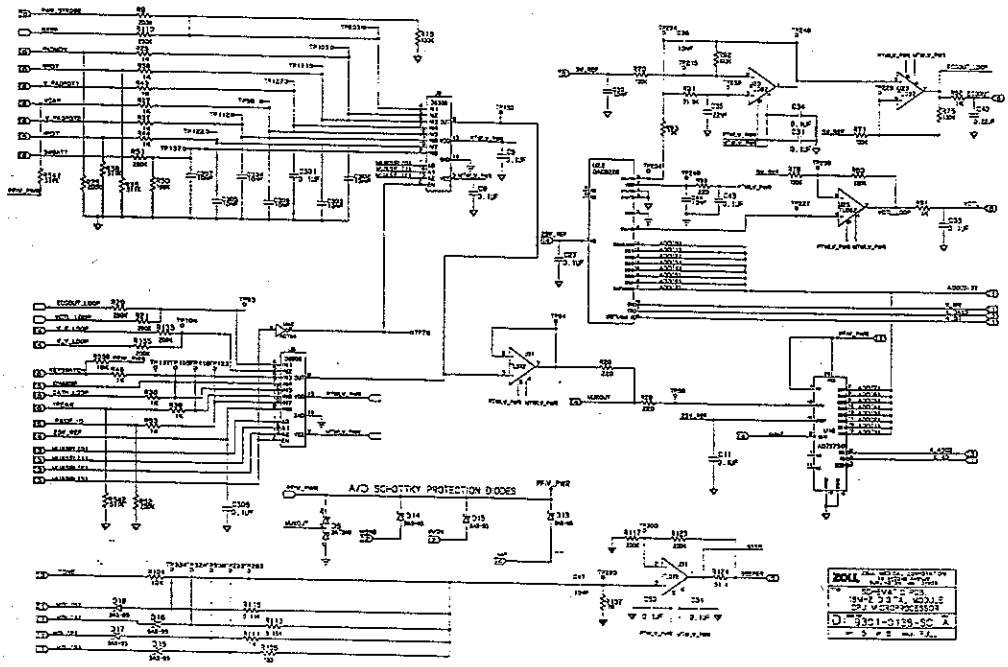

SC-EVA
POWER SUPPLY PD1400
9301-0102-SC A

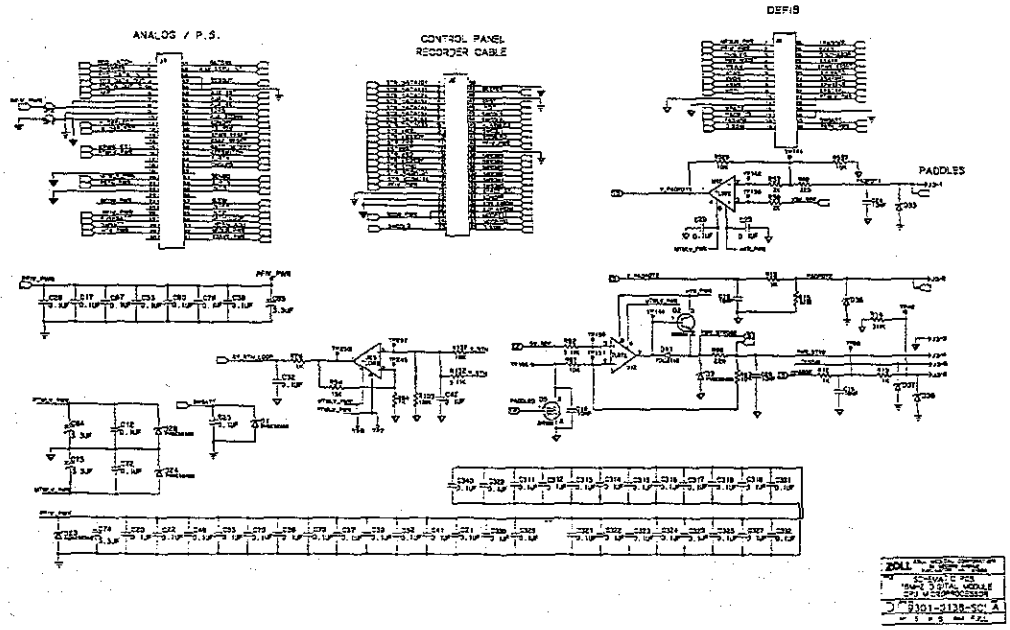


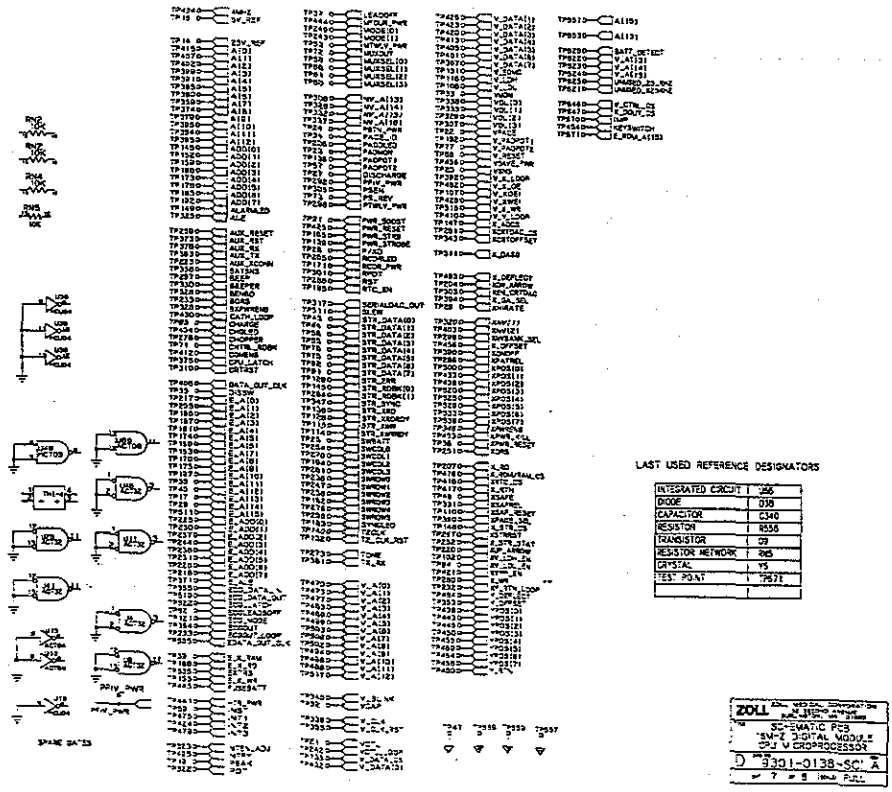







A/D SCHOTTKY PROTECTION DIODES


ANALOG / P.S.
CONTROL PANEL
RECORDER CABLE
DEFIB
PADDLES



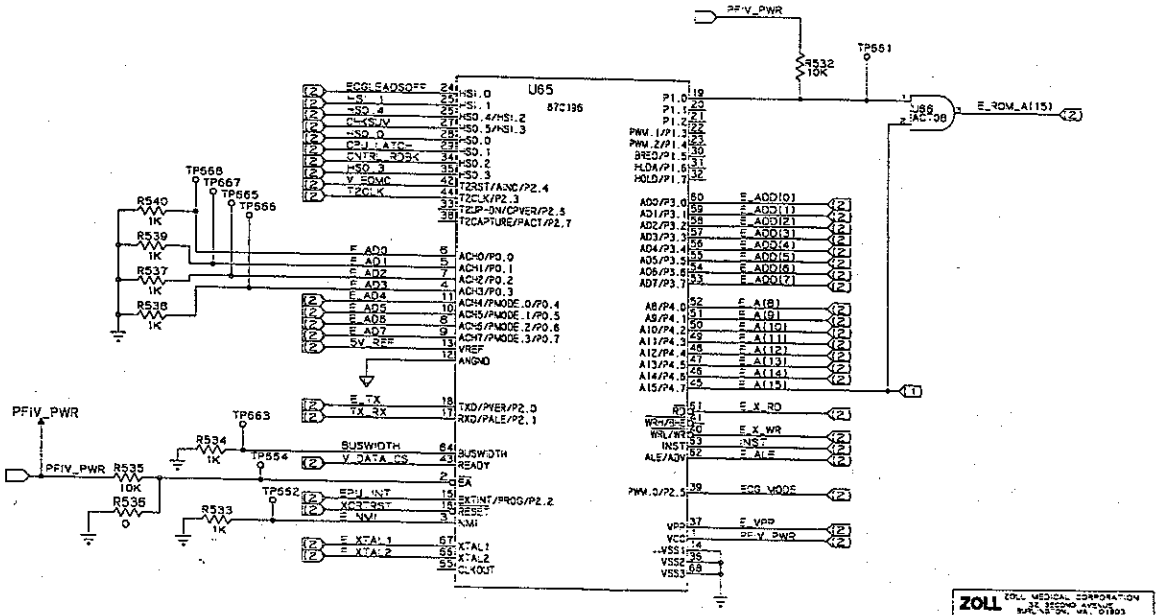
LAST USED REFERENCE DESIGNATORS

INTEGRATED CIRCUIT	U66
DIODE	D38
CAPACITOR	C340
RESISTOR	R556
TRANSISTOR	Q9
RESISTOR NETWORK	RN5
CRYSTAL	Y5
TEST POINT	TP671

ZOLL

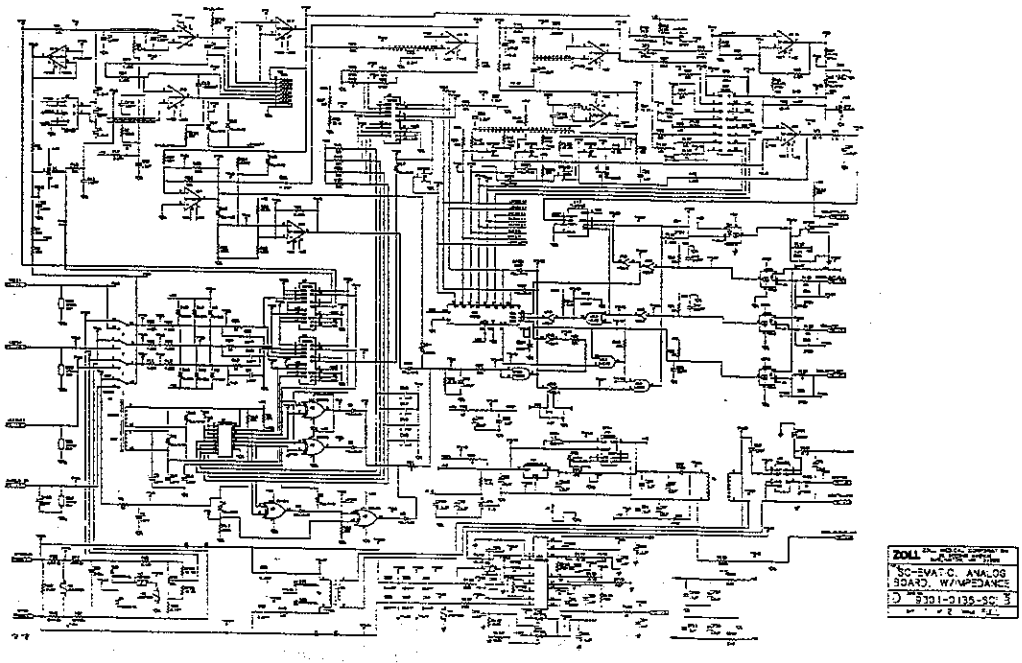
SCHEMATIC PCB
"SAM" DIGITAL MODULE
SAM W CROSSOVER

D 3301-0138-SC A



NOTE: U65 IS INSTALLED ON THE 9301-0138-02 ASSEMBLY.
U3 IS INSTALLED ON THE 9301-0138-01 ASSEMBLY.

ZOLL MEDICAL CORPORATION
SCHEMATIC PCB
15MHZ DIGITAL MODULE
CPU MICROPROCESSOR
9301-0138-SC A


ZOLL
SCHEMATIC, ANALOG
BOARD, W/IMPEDANCE
9301-0135-SCH